November 1986

YAKIMA RIVER SPRING CHINOOK ENHANCEMENT STUDY

Annual Report 1986

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YAKIMA RIVER SPRING CHINOOK ENHANCEMENT STUDY

Annual Report FY 1986

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2.0 ABSTRACT

A total of eight spring chinook redds were successfully capped in 1986. The mean survival to emergence was 56.7 % and ranged from 21.9 to 90.0 %.

The smolt outmigration was monitored at Wapatox on the Naches River and Prosser on the lower Yakima. The spring outmigration at Wapatox was estimated to be 6,671 smolts. The 1986 outmigration of wild spring chinook from the Yakima Basin was estimated to be 169,076 smolts at Prosser.

The survival from egg to smolt was calculated using the 1984 redd counts and the 1986 smolt outmigration at Prosser. The estimated survival was 4.6 %, which gives a mean egg to smolt survival over four years of 5.1 %.

In 1986 a total of 8,557 adult and 349 jack spring chinook salmon returning to the Yakima River were counted at Prosser fish ladder. This gives a total of 8,906 salmon returning to Prosser Dam. The median dates of passage were May 18 and May 26 for adults and jacks respectively. An additional 530 fish were estimated to have been caught in the Yakima River subsistence dipnet fishery below Horn Rapids and Prosser Dams. Therefore, total return to the Yakima system was 9,442 spring chinook salmon. This was the largest return of spring chinook salmon to the Yakima River in 29 years.

Spring chinook were counted at Roza Dam from May 13 to September 30, 1986. Passage at Roza Dam was 2,967 adult and 284 jack spring chinook for a total of 3,251 fish. The median dates

of passage at Roza Dam were June 6 and June 23 for spring chinook adults and jacks respectively.

The smolt to adult (S_{sa}) survival was calculated based on the 1983 smolt outmigration estimated at Prosser and the 1984 return of jacks (3 year old fish), the 1985 return of four year old adults, and the 1986 return of five year old fish to the Yakima River. It was estimated that 6,102 wild three, four, and five year old fish returned from an estimated smolt outmigration of 135,548 fish in 1983. This gives an estimated survival from smolt to adult of 4.4%.

The smolt to adult survival for the 1984 smolt outmigration was 4.5% with 423 jacks returning in 1985 and 5,163 four year old adults returning in 1986 from an estimated 123,732 smolts in 1984.

Spring chinook adults from eight different hatchery release groups were recovered in 1986. A total of 31 coded wire tags were recovered and these were expanded to an estimated 65 returning hatchery fish in 1986. Four of these fish were jacks.

3.0 INTRODUCTION

The population of Yakima River spring chinook salmon (Oncorhynchus tshawytscha) has been drastically reduced from historic levels reported to be as high as 250,000 (Smoker, 1956). This reduction is the result of a series of problems including mainstem Columbia dams; dams within the Yakima itself; severely reduced flows due to irrigation diversions; outmigrant loss in irrigation canals; increased thermal and sediment loading; and overfishing. Despite these problems, the escapement of spring chinook to the Yakima River has continued at levels ranging from 166 to 9,442 since 1957.

In October, 1982, the Bonneville Power Administration contracted the Yakima Indian Nation to develop methods to increase production of spring chinook in the Yakima System. The Yakima Nation's current enhancement policy attempts to maintain the genetic integrity of the spring chinook stock native to the Yakima Basin. Relatively small numbers of hatchery fish have been released into the basin in past years. Data from the Wenatchee System indicate a return rate from hatchery smolts of less than .25% (Mullan, 1982). Return rates from the current Yakima study smolt releases are .07%. These low return rates indicate that few fish would have returned from these early hatchery releases. Thus the genetic input from hatchery fish into Yakima Basin stocks is probably negligible.

The goal of this study is to develop data that will be used to present management alternatives for Yakima River spring chinook. The study has five major objectives. The first objective is to determine the distribution, abundance and survival of wild Yakima River spring chinook. Naturally produced populations are being studied to determine if these runs can be sustained in the face of present harvest and environmental conditions. Survival through each life stage is being evaluated in an attempt to determine limitations to natural production in the basin. Survival to emergence studies are being conducted to determine survival through the incubation stage. Analysis of the relationship between survival to emergence and gravel substrate quality is being undertaken. Seining at selected sites and electroshocking surveys have been conducted to evaluate distribution and abundance of juvenile fish. Smolt outmigrations are monitored at the Wapatox juvenile trap on the Naches River and at the Prosser juvenile trap on the mainstem Yakima River. Adult returns are determined by monitoring the Yakima Tribal dipnet fishery, counting adults at Prosser and Roza fish ladders, and through spawning ground surveys. Physical parameters such as water temperatures and stream flow are monitored throughout the basin.

The second major objective of this study is to determine the relative effectiveness of different methods of hatchery supplementation. This objective is divided into three sub-objectives:

a) Determination of optimal release time Smolt releases are the norm, but fingerlings were released in June, September, and November of 1984 and 1985. Downstream survival of these smolts will be evaluated and adult returns will be monitored.

b) Determination of optimal manner of release In the past, fish have either been transported from a hatchery and released into the Yakima River, or raised in rearing ponds. These methods, as well as the use of acclimation ponds, will be evaluated.

c) Determination of optimal release stocks Smolts will be released as hatchery X hatchery, hatchery X wild, and wild X wild crosses to determine the effect of genetic makeup on the success of various releases. Success will be measured as the number of adults returning, as well as whether spawning timing is similar to the wild stock.

Adverse interactions between hatchery releases and wild stocks will be minimized by scatter-planting hatchery fish so densities in the river will remain low enough to minimize competition for food and space.

The last three major objectives of the study are:

3) to locate and define areas in the watershed which may be used for the rearing of spring chinook;
4) to define strategies for enhancing natural production of spring chinook in the Yakima River; and
5) to determine the physical and biological limitations on production within the system.

These objectives will be met at the end of the study when the database is complete.

This project is a multi-year undertaking that will evaluate different management and enhancement strategies. At the conclusion of this study, a series of alternatives will be developed that can be used to determine how best to enhance the runs of spring chinook in the Yakima Basin. Annual reports were presented in 1983 (Wasserman and Hubble, 1983), 1984 (Wasserman, Hubble, and Watson, 1985) and 1985 (Fast, Hubble, and Watson, 1986). A detailed description of methods and materials used in this study can be found in these earlier reports. This current report is concerned with new findings in 1986 and some re-evaluation of previous data in light of current information.

4.0 DESCRIPTION OF STUDY AREA

The Yakima River is located in central Washington and flows 217 miles from its headwaters in the Cascade Mountains (elevation 2,448 ft) to the Columbia River near Richland at river mile (RM) 335 (Figure 1). The Yakima River Basin drains 6,155 square miles of the east slopes of the Cascade Mountains in Kittitas and Yakima Counties. The Yakima River flows east and south through the Kittitas Valley from its ruggedly glaciated headwaters. South of the valley the river cuts through Manastash and Umtanum ridges in a deep canyon. The river enters the middle valley above Yakima through a gap cut in Selah Ridge and leaves through Union Gap in Ahtanum Ridge. Rattlesnake Hills, crossing eastern Yakima and northern Benton Counties, and the Horse Heaven Hills to the south are prominent features bordering the lower river in its 80 mile reach from Union Gap to the Columbia River. The Yakima River enters the Columbia River near Richland at an elevation of 300 feet.

The major tributaries, with the exception of Satus and Toppenish Creeks, enter the river above the city of Yakima. The Naches River is the largest tributary, entering the Yakima at RM 101 and extending 51 miles to the junction of the Bumping and Little Naches Rivers. The Naches River drains an area of 1,106 square miles. Other important tributaries of the Naches include the American and Tieton Rivers and Rattlesnake Creek.

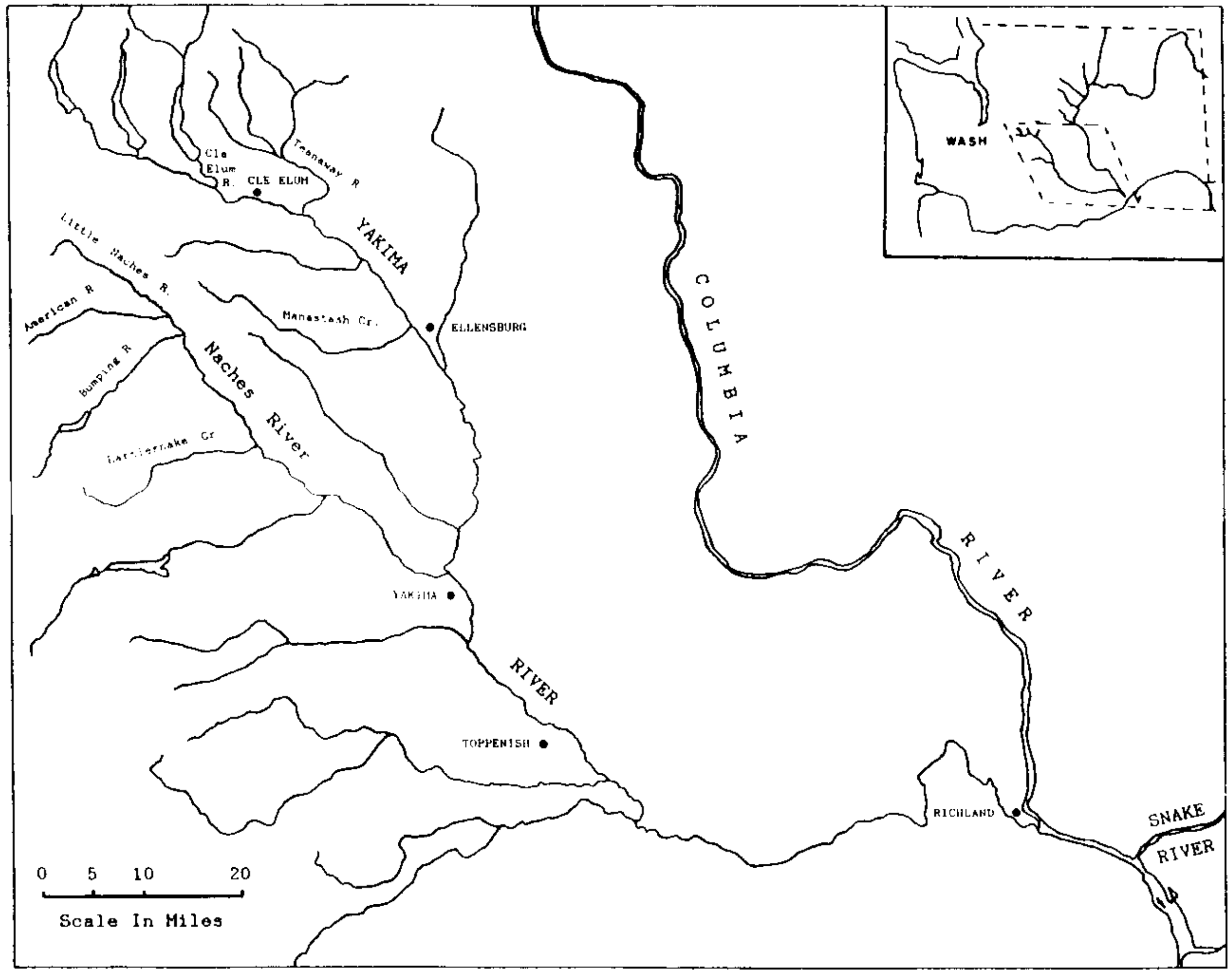


Figure 1. Study area on the Yakima River system.

Important tributaries in the upper Yakima are the Teanaway and Cle Elum Rivers. Numerous creeks, including Manastash, Taneum, and Swauk, flow into the Yakima in the Kittitas Valley. The climate of the Yakima Basin varies from wet-alpine in the Cascade Mountains to semi-arid conditions at the lower elevations. The crest of the mountains receive 80 to 140 inches of precipitation per year while approximately one third of the basin receives ten inches or less. Summer temperatures average 55 F in the mountains and 82 F in the valleys. During the winter monthly maximum temperatures range from 25 F to 40 F and low temperatures range from -20 F to -25 F.

The Yakima River Basin produces 3.5 million acre feet average annual runoff, unregulated. The U.S. Bureau of Reclamation's Yakima Irrigation Project has transformed the semi-arid region into a productive agricultural region. Approximately 500,000 acres are presently under irrigation, consuming 2.25 million acre feet each year. There are numerous dams and irrigation diversions on the river. These include Horn Rapids, Prosser, Sunnyside, Wapato, Roza, and Easton. A screening structure is associated with each of these dams except at Easton. For an extensive description of the Yakima Basin, see Bryant and Parkhurst (1950).

In the Yakima system, reservoir storage acts to regulate flows. Man-made Kachess, Keechelus, and Cle Elum Lakes in the upper Yakima and Bumping and Rimrock Lakes on the Naches system are the major storage sites. These storage areas supplement flows during the irrigation season (March-October) and store water in the winter. Irrigation and power diversions generally reduce flows in the lower sections of the Yakima River. Sunnyside and Wapato dams near rivermile 108 divert approximately one-half the total river flow at each site into irrigation diversions in the summer and fall. Prosser diversion removes approximately 1,400 cfs for irrigation and power production throughout most of the year. Due to the large irrigation diversions at Prosser and Parker, flows drop dramatically in the lower river from June to October. Approximately 50% of the flows withdrawn at diversion sites re-enter the river downstream after being used for irrigation or hydropower.

Prior to 1980, flows remained high on the spawning grounds in September and October for irrigation purposes. Many fish that spawned at this time deposited their eggs in shallow water near the bank. When flows were decreased at the end of the irrigation season, these redds were often dewatered. Following court action in 1981 the irrigation flows were decreased in the Yakima branch during the first week of September so that this problem would not continue. To offset the reduction of flows from the upper Yakima in September, flow is increased in the Naches River from Bumping and Rimrock Reservoir releases.

5.0 METHODS AND MATERIALS

5.1 NATURAL PRODUCTION

5.1.1 SURVIVAL TO EMERGENCE STUDIES

5.1.1.1 Fry Trapping

Methods for identifying redds and capturing spent female spawners on the spawning grounds were detailed in Wasserman and Hubble (1983). In early February 1985, redd caps (1/8" mesh) were placed over nine previously selected redds in the upper Yakima River between Easton and Cle Elum (Figure 1). Redd cap design followed that of Tagart (1976). Caps were constructed to extend a distance of at least one meter from the crown of the redd on all sides. Edges of the cap were buried to a depth of nine inches. All caps were installed by March 17, 1986, and each was checked at least twice weekly until the first fish was captured. Thereafter traps were checked daily except when high flows prevented sampling. Survival to emergence was calculated as the total number of captured emergent fry divided by the estimated number of eggs deposited in each redd.

The number of eggs deposited was calculated using a length-fecundity model developed from 20 females sampled during the spawning ofthe 1985 brood stock, and three large unspawned females collected in 1986. The mean weight of four 100-egg samples was determined for each female. The weight per egg was calculated and applied to the weight of the total egg mass to estimate individual fecundity. The length-fecundity model was then generated by regressing fecundity on fork length for these 23 observations.

Temperature unit (T.U.'s) calculations were derived from thermograph data collected at the Bureau of Reclaimation gauging station on the Yakima River (RM 183). Temperature units aquired for a given day were calculated by subtracting 32^{o}F from the mean daily temperature.

5.1.1.2 Gravel Analysis

Four gravel samples were taken on each riffle where a redd was capped. Regression analysis was undertaken to determine the relationship between survival to emergence and the size composition of spawning gravel. For seven redds successfully capped in 1986, gravel size composition was analyzed by determining the percent of the entire gravel sample retained in each of 10 sieves (sizes 75mm, 26.5mm, 13.9mm, 9.5mm, 6.7mm, 3.35mm, 1.7mm, .85mm, .425mm, and .212mm). This follows the methodology of Tagart (1976). The quality of gravel associated with study redds was assessed in terms of the fredle index (Lotspich and Everest, 1981).

The fredle index (f_i) is calculated by the equation

$$f_i = dg/s_o$$

where dg = mean geometric diameter of the sample,

s_o = sorting index = $(d_{75}/d_{25})^{1/2}$,

and d_{75} and d_{25} are grain sizes at the 75th and 25th percentile, respectively.

The relationship between size composition of spawning gravel and survival to emergence was assessed by regressing survival to emergence on the fredle index.

5.1.2 DISTRIBUTION STUDIES

5.1.2.1 Beach Seining

The rearing density of juvenile spring chinook at several gravel bars in the Yakima River upstream of the confluence with the Naches River was estimated in September, 1986. Population was estimated by the Leslie removal method (Ricker, 1975), using a 100 x 8 foot beach seine with 1/4 inch mesh. Seining was conducted in glides at the interface between the main current and slower water near the bank. Water depth was normally 3 to 5 feet deep. Sets were initiated at the uppermost end of a glide. Sets were conducted by an individual running with the seine towards mid-stream, and then swinging downstream until the net was fully extended. A second individual guided the net out and a third anchored the lead line to the shore. A boat with a jet pump was used at sites where deep water prevented running with the net. Sets were made on the same glide until either no spring chinook were captured, or until five sets were conducted. Rearing density was calculated as the ratio of the Leslie population estimate to the measured area of the gravel bar.

5.1.2.2 Electroshocking Surveys

Electroshocking was conducted in tributaries not previously sampled in the Yakima and Naches Rivers during the summer of 1986. Sampling was conducted using a Smith-Root Type-VII backpack electroshocker. Only salmonid species were collected. Fish collected were anesthetized with MS-222. Data collected included identification of species, numbers of fish, and fork lengths. Stream measurements were taken for later determination of population densities. The Leslie Method was used to estimate population (Ricker, 1975)

5.1.3 PROSSER SMOLT TRAP

Prosser smolt trap was operated continuously from February 23 to July 31, 1986, and one day per week from August 1 through October 15. Prosser trap operates from a bypass pipe that shunts fish from rotary drum screens in Chandler Canal back to the mainstem Yakima River. In 1984 and 1985 trapping efficiency (the percentage of outmigrants passing Prosser Dam diverted into the trap) was calculated via a series of releases of marked fish. The statistical methodology for efficiency calculations was evaluated by Douglas Chapman of the University of Washington Center for Quantitative Science. A detailed description of the evaluation process can be found in Appendix B. of this manuscript. The basic procedure was as follows. Once each week, fish captured in the trap during the night were cold-branded. Two groups were branded differently, with one group released two miles upstream of the canal intake, and the other in the canal. Efficiency (E_i) was based on the recapture rate of branded fish as follows:

$$E_i = \frac{C_{ri}}{R_{ri}\ (C_{ci}/R_{ci})}$$

where E_i = fraction of fish diverted into the canal in the ith experiment;
R_{ci} = number released directly into the canal in the ith experiment;
R_{ri} = number released directly into the river in the ith experiment;
C_{ci} = number recaptured from the canal release in the ith experiment;
and C_{ri} = number recaptured from the river release in the ith experiment.

During the 1984, 1985 and 1986 spring chinook smolt migrations a total of 28 separate efficiency tests were performed.

A relationship was developed between the combined 1984-86 efficiency data and mean river discharge (see Appendix B for details). Four simultaneous tests using spring chinook and steelhead and one test using spring chinook and hatchery coho were performed. The results of these tests with steelhead and hatchery coho were comparable to the results of the spring chinook tests.

5.1.4 WAPATOX SMOLT TRAP

The purpose of Wapatox smolt trap is to monitor the spring chinook smolt outmigration in the spring and the pre-smolt outmigration the rest of the year. Wapatox smolt trap is located on the Naches River at RM 17, just downstream from the confluence of the Tieton and Naches Rivers (see Figure 1). The trap is constructed on the Wapatox by-pass canal. Fish entering the canal are shunted into a by-pass pipe (culvert) by a series of rotating drum screens across the diversion canal.

Wapatox smolt trap began operation on March 22, when the rotary drum screens were put into place. The trap was normally checked at least 5 times per week and more often during peak migration periods. Only salmonid species were enumerated. Fish were anesthetized with MS-222 and fork lengths and weights were recorded.

An attempt was made again this year to determine trap efficiency as an empirical function of the percent discharge diverted into the canal (P.D.C.) by making a series of releases of marked fish at various discharges as was done at Prosser smolt trap (see Fast et. al., 1984 and 1986). Unfortunately, too few smolts were captured during the spring outmigration to have both significant sample sizes and enough test releases to generate a meaningful regression of efficiency on P.D.C. Therefore, the only recourse was simply to assume trapping efficiency was equivalent to P.D.C. as follows:

Efficiency = P.D.C. = (Canal flow/river flow facing dam) x 100

This assumption probably does not hold at many river discharges. At Prosser smolt trap, the assumption of "equal numbers of fish in equal volumes of water" overestimates efficiency at low river discharge and underestimates efficiency at high river discharge (Fast et. al., 1986, Appendix B).

When the trap was inoperable, an estimate of the daily catch was made by using the mean daily catch from the two days preceeding and following the closure.

5.1.5 LOST CREEK PONDS

Lost Creek Ponds are located next to the Naches River at RM 38.7. They consist of two ponds, the upper pond being approximately 40m x 30m and the lower pond being approximately 100m x 20m. Pond depths range from 0.5m to 1.5m. Water flow to the ponds is supplied by a small diversion ditch, which diverts flow from the Naches River, and by groundwater seepage from the river. The lower pond returns flow back to the river.

In past years juvenile spring chinook have been observed rearing in these ponds. In late February, 1986 traps were installed at both the inflow diversion ditch and at the outlet of the lower pond to determine the extent of rearing in these ponds. Both traps were monitored through August.

Spring chinook captured in the inflow trap were enumerated and freeze-branded, using a dry ice and acetone slurry. Branded fish were held 24 hours for recovery prior to release below the trap. Four different brand codes were used throughout the trapping period. The same brand code was used in March and April, then was switched in May and again in June. A fourth brand code was used in both July and August. Fork lengths were taken from a portion of the daily catch.

Not every spring chinook captured at the outlet trap was branded. Sources of unmarked fish included fry resulting from the spawning of brood stock held in the lower pond, and fry that entered the pond when the inflow trap was not fish-tight during periods of high discharge. Branded fish recaptured in the outlet trap were enumerated and their fork lengths were recorded.

5.1.6 ADULT RETURNS

Adult spring chinook salmon harvested below Prosser in the 1986 Yakima Tribal ceremonial dipnet fishery were monitored under the BIA 638 contract.

The Prosser and Roza Dam adult fish counting stations were monitored in 1986. Counting at Prosser began April 1 and continued through August. Roza Dam was monitored from May 13 through September 30. Water clarity at Roza Dam was such that fish swimming over the counting board could be visually examined for the presence or absence of an adipose fin. All adipose-clipped fish were collected in a second trap and sacrificed to recover the coded wire tags.

Spawning ground surveys were inititated on the American River in mid-July as part of a coordinated effort between the Yakima Indian Nation, the U.S. Fish and Wildlife Service, Washington Department of Fisheries, and the Bureau of Reclamation. The Yakima Indian Nation was the lead agency under a contract from the Columbia River Inter-Tribal Fish Commission. Spawning ground surveys were conducted throughout each reach of spawning area once each week. All carcasses were examined for adipose fins, and fork length and mid-eye to hypural plate length were recorded. Scale samples were taken, and gonads were examined to determine sex and egg retention in females. Following examination the tail of each fish was removed so it would not be examined more than once.

Several helicopter flights of the Yakima system were made in conjunction with the Bureau of Reclamation during the spawning period to determine spawning timing and general location of redds.

5.1.7 ESTIMATES OF SURVIVAL THROUGH VARIOUS LIFE STAGES

5.1.7.1 Egg to fry:

As previously discussed, survival from egg deposition to emergence was investigated. Total egg deposition was calculated as mean fecundity of Yakima River females (based on the length fecundity model) multiplied by the number of redds located on the spawning grounds.

The total number of fry produced (F) was calculated as:

F = mean fecundity of Yakima River spawners x number of redds x survival from egg deposition to emergence.

5.1.7.2 Egg to Smolt:

Survival from egg to smolt (S_{es}) was calculated as:

$$S_{es} = \frac{\text{estimated number of smolts at Prosser}}{\text{total egg deposition for year class.}}$$

5.1.7.3 Fry to Smolt:

Survival from fry to smolt (S_{fs}) was estimated as:

$$S_{fs} = \frac{\text{number of smolts estimated to pass Prosser}}{\text{fry for year class}}$$

Estimates of egg deposition and fry production were made for 1981 to 1985 based on redd counts from spawning ground surveys. Survival from egg to smolt and from fry to smolt were based on 1981, 82, 83 and 84 redd counts and 1983, 84, 85 and 86 outmigration estimates at Prosser.

5.1.7.4 Smolt to Adult:

The smolt to adult survival (S_{sa}) of wild spring chinook salmon in the Yakima system was calculated from the 1983 smolt outmigration estimated at Prosser and the 1984 return of jacks (3 years old fish), the 1985 return of four year old adults, and the 1986 return of five year old adults.

PART 2

5.2 HATCHERY OPERATIONS

5.2.1 OUTPLANTING STUDIES

5.2.1.1 Pre-Smolt Releases

Groups of approximately 100,000 juvenile spring chinook (fry to pre-smolts) were released into the upper Yakima River in June, September, and November of 1985 to determine the optimum timing for hatchery releases. Similar releases were made in 1984. The fry, fingerlings and pre-smolts released in 1985 were from the Leavenworth Fish Hatchery 1984 brood year. The fish were reared at Leavenworth and trucked to the Yakima River and scatter-planted at 12 sites between RM 155 and 200. All fish were coded-wire tagged and approximately 10% were cold branded.

5.2.1.2 Smolt Releases

The effectiveness of hatchery-reared "native" (wild x wild) and "hybrid" (wild x hatchery) vs. "hatchery" (hatchery x hatchery) smolts was assessed by transporting three such groups to Mary's Pond (RM 190, Yakima River) and allowing them immediate volitional release. Fish were transported from Leavenworth National Fish Hatchery and stocked into the pond over the period March 26 through March 28, 1986. Release began the night of March 28. Similar releases were made from Nile Springs pond in 1983 and 1984, although these releases involved only hatchery smolts. A second group of hatchery x hatchery smolts was transported from

Leavenworth National Fish Hatchery and released directly into the upper Yakima River (12 sites between RM 155 and 200) on April 9 and 28, 1986. All fish released in 1986 were coded-wire tagged, and approximately 13% of the pond fish and 12.6% of the fish released directly into the river were cold-branded.

Counts of branded hatchery smolts captured at Prosser smolt trap were used to evaluate freshwater survival of both groups of fish. Based on brand recoveries alone the relative survival of each group was calculated. Total estimated passage of each group yielded absolute survival rate estimates to Prosser. Smolt to adult return rates of these two groups will be determined in 1987 and 1988 from captures of tagged fish in the ocean, mainstem Columbia River fisheries, the tribal dipnet fishery on the Yakima River, and from carcass recoveries on the spawning grounds.

5.2.2 BROOD STOCK EVALUATIONS

Hatchery spring chinook introduced into the Yakima River from 1950 to 1984 have come from numerous sources and stocks (Table 1), although, as previously mentioned, their contribution to the genome of naturally spawning Yakima River fish has probably been minimal. An experimental brood stock program was undertaken in 1984 and continued in 1985 to evaluate the benefits of using spring chinook from the Yakima River as a source of gametes. The purpose was to culture indigenous fish and to determine the optimal stock for enhancement programs.

The best stock for enhancement programs will be determined by a comparison of returns of adult fish from four release groups: (1) a pond-acclimated group of hatchery-reared "hybrids"(Yakima River males crossed with Leavenworth Hatchery females), (2) an acclimated group of hatchery-reared "natives" (Yakima males crossed with Yakima females), (3) an acclimated group of pure hatchery smolts (Leavenworth males crossed with Leavenworth females), and (4) a group of pure hatchery smolts released directly into the river. Groups 1-3 will be allowed volitional release from an acclimation pond in the upper Yakima River. These groups will be used to determine if cultured fish that are the progeny of Yakima River spring chinook have a greater success in returning to the Yakima River than do non-indigenous stocks. The fourth group will be used as a control on the value of acclimating spring chinook in ponds for various periods before allowing volitional release. Returns from group four will be compared directly to group three.

Table 1. Historical plants of spring chinook in the Yakima River Basin.

Brood year	Release date	Hatchery	Size fish/Lb	Number released	Brood stock	Release location
1958	8/59	Klickitat	143	20,000	Klickitat	Yakima River
1960	5/61	Leavenworth	330	18,000	Icicle	Yakima River
1961	2/62	Leavenworth	1000	5,000	Icicle	Yakima River
1962	12/62	Leavenworth	1000	5,000	Icicle	Yakima River
1962	63			12,500		Nile Springs
1963	64			10,000		Nile Springs
1971	6/73	Klickitat	58	162,400	Klickitat	Naches River
1971	6/73	Klickitat	58	162,400	Klickitat	American River
1974	75			8,580		Nile Springs
1974	4/76	Ringold	3	7,230	Ringold	Nile Springs
1974	9/76	Klickitat	29	42,775	Klickitat	Nile Springs
1975	3/77	Klickitat	19	13,300	Klickitat	Nile to Richland
1976	3/78	Klickitat	7	2,462	Cowlitz	Nile Springs
1977	4/79	Carson	20	50,000	Carson	Yakima River
1977	4/79	Klickitat	12	25,000	Cowlitz	Nile Springs
1978	4/80	Klickitat	10	24,000	Klickitat	Nile Springs
1978	4/80	Leavenworth	18	30,260	Carson	Yakima River
1979	4/81	Klickitat	14	33,616	Klickitat	Nile Springs
1979	4/81	Leavenworth	20	400,221	Leavenworth	Yakima River
1980	4/82	Leavenworth	14	100,050	Leavenworth	Nile Springs
1980	4/82	Leavenworth	15	401,714	Leavenworth	Yakima River
1981	4-5/83	Leavenworth	18	103,110	Leavenworth	Nile Springs
1981	4/83	Leavenworth	19	97,012	Leavenworth	Yakima River
1982	4/84	Entiat	19	29,636	Carson	Nile Springs
1982	4/84	Entiat	25	42,552	Carson	Yakima River
1983	6/84	Leavenworth	66	102,837	Carson	Yakima River
1983	9/84	Leavenworth	25	102,833	Carson	Yakima River
1983	11/84	Leavenworth	22	108,305	Carson	Yakima River
1983	4/85	Leavenworth	18	50,000	Carson	Yakima River
1984	6/85	Leavenworth	66	100,000	Leavenworth	Yakima River
1984	9/85	Leavenworth	25	100,000	Leavenworth	Yakima River
1984	11/85	Leavenworth	22	100,000	Leavenworth	Yakima River
1985	3/86	Leavenworth	21	51,846	Carson	Yakima River
1985	4/86	Leavenworth	20	50,657	Carson	Yakima River
1985	3/86	Leavenworth	17	46,476	Carson/Yakima	Yakima River
1985	3/86	Leavenworth	17	33,052	Yakima	Yakima River

Note: Native spring chinook broodstock in Klickitat River at times was supplemented with Carson, Cowlitz, Eagle Creek, and Williamette Fish.

5.2.3 ADULT HATCHERY RETURNS

Six groups of adult hatchery fish returned to the Yakima River in 1986. These groups were identified by the coded-wire tags recovered in the spawning ground surveys and carcass recovery surveys conducted in September and October of 1986. Recoveries included survivors of the acclimated smolts released in the spring of 1983 and 1984 (Nile Springs pond), survivors of the acclimated smolts released in the spring of 1985 (Mary's pond), survivors of the non-acclimated smolts released in 1983 and 1984, and survivors of the November, 1984 release of pre-smolts.

The recoveries from the 1983 release groups were returning as five year old fish and complete the data necessary to calculate the total survival (jacks, four-year fish, and five-year fish) from smolt to adult for that release.

The recoveries from the 1984 release groups were for four year old fish only since this was the first year that fish released in 1984 returned as adults (no hatchery jacks were reported in 1985).

Coded-wire tags were recovered from four sources; the Yakima Indian Nation Zone 6 ceremonial and subsistence fishery in the Columbia River, the Yakima dip net fishery, the spawner surveys and carcass recovery surveys in the Naches River, and from the adult trap at Roza Dam. All tags recovered were expanded by the sample rate (fish sampled/total number of fish caught for a fishery or carcasses sampled/total number of spawners estimated in each river for spawner surveys) and by the mark rate or coded-wire tag retention rate.

Survival rate for hatchery smolt to adult was calculated by dividing the total expanded return of adults from each release by the estimated passage of smolts by Prosser from that release. The expanded return numbers were also divided by the total number of smolts released in each group to obtain a hatchery planting to adult survival rate.

6.0 RESULTS AND DISCUSSION

6.1 NATURAL PRODUCTION

6.1.1 SURVIVAL TO EMERGENCE STUDIES

6.1.1.1 Fry Trapping

Survival to emergence studies were successfully carried out on eight of the nine redds capped in March, 1986. The females spawning in the study redds were captured between September 13 and September 27, 1985 (Table 2). The unsuccessful redd had 124 fry in the net the first day it was checked. It had 18 fry the second day, and no fry were collected after that. From this data we assume that emergence had occurred before we capped the redd. This redd was not included in the analysis.

The mean survival from egg deposition to emergence of the eight successfully capped redds was 56.7% and ranged from 21.9 to 90.0% (Table 3). This is much higher than the 20.6% mean and 13.0 to 30.6% range of survival to emergence reported in 1984 but very close to the 62.5% (29.3 to 84.4%) reported in 1985. Daily totals and cumulative captures for the capped redds are given in Appendix Tables A.1 through A.4.

It is believed that more fry were captured in 1985 and 86 because of modifications to the redd cap net. The addition of liveboxes at the cod end of the net and the placement of vexar under the net reduced the number of fry which previously may have escaped through small holes caused by gravel abrasion.

Table 2. Location of redds and size of females captured in September 1985 for 1986 survival to emergence studies.

Location	Date captured	Fork length (mm)	ME-HP (mm)[a]
Salmon La Sac	9/19/85	750	600
Sun Country 1	9/21/85	680	560
Sun Country 3	9/26/85	770	700
Elk Meadows 1	9/13/85	770	620
Elk Meadows 2	9/26/85	775	620
LDS	9/21/85	680	570
Runacres	9/24/85	695	570
Side Channel	9/27/85	760	640

[a]ME-HP = mid-eye to hypural plate length.

The current results are consistant with laboratory studies conducted by Tappel and Bjornn (1983) in which survival ranged from 66 to 88% studies conducted by Koski (1975) indicated the survival to emergence of chum salmon in experimental channels ranged from 7.2 to 88.4% in three years of study, and the annual mean survival ranged from 25.6 to 57.9%

The temperature units (T.U.'s) required for spring chinook emergence in 1986 are presented in Table 4. The mean number of T.U.'s required for 50% and 100% emergence was 1,621 and 2,303, respectively. These numbers coincide very closely with the means of 1,967 and 2,291 T.U.'s required for 50 and 100% emergence in the redds capped in 1984, and the 1,937 and 2,215 T.U.'s for 1985 redds. A length-fecundity model was developed based on twenty Yakima River spring chinook females sampled during the spawning of the 1985 brood stock and three large unspawned female carcasses found in the Naches River (Figure 2). A statistically significant ($p < .05$, $r = +0.95$) linear regression model was developed from the twenty-three length fecundity points (Table 5).

The equation that best fits this regression line was

$$Y = 15.62\ (X) - 7305$$

where Y = estimated number of eggs at fork length X,

and

X = fork length in millimeters.

This equation was applied to the length measurements of the females captured for the survival to emergence studies and the number of eggs deposited in each redd was calculated (Table 3).

6.1.1.2 Gravel Analysis

Analysis was undertaken to determine the relationship between gravel quality and survival to emergence. The fredle index, as described by Lotspich and Everest (1981) and the corresponding survival to emergence for each redd is presented in Table 6. There was no significant relationship between survival to

Table 3. Results of 1986 Yakima River survival to emergence studies.

Location	Spawning date	Female fork length (mm)	Estimated number of eggs deposited[a]	Number of emergent fry	% survival	Date of 1st emergence	Date Of 50% emergence
Salmon La Sac	09-19-85	750	4,435	3,356	75.7	04-22-86	05-07-86
Sun Country 1	09-21-85	680	3,256	2,683	82.4	04-11-86	04-21-86
Sun Country 3	09-26-85	770	4,756	1,495	31.4	03-25-86	03-26-86
Elk Meadows 1	09-13-85	770	4,664	1,524	32.7	04-08-86	04-21-86
Elk Meadows 2	09-26-85	775	4,798	1,504	31.3	04-06-86	04-23-86
LDS site	09-21-85	680	3,293	2,900	88.1	04-17-86	04-28-86
Runacres	09-24-85	695	3,423	3,081	90.0	04-24-86	04-29-86
Side channel	09-27-85	760	4,586	1,003	21.9	04-04-86	04-18-86
Mean		735	4,151	2,193	56.7[b]		

[a]Estimated fecundity minus eggs retained in female.

[b]This number is the mean of six, individual survival rates, and is not the same as the ratio of the overall mean number of emergent fry (2,193) to the overall mean number of deposited eggs (4,151).

Table 4. Temperature units (T.U.'s) required for spring chinook emergence in 1986.

Location	Spawning Date	Date of 1st Emergence	T.U.'s Required	Date of 50% Emergence	T.U.'s Required	Date of 100% Emergence	T.U.'s Required
Salmon La Sac	09/19/85	April 22	1688	May 7	1875	June 16	2571
Sun Country 1	09/21/85	April 11	1505	April 21	1632	June 11	2444
Sum Country 3	09/26/85	March 25	1211	March 26	1221	April 11	1397
Elk Meadows 1	09/13/85	April 8	1650	April 21	1811	June 11	2623
Elk Meadows 2	09/26/85	April 6	1337	April 23	1549	May 31	2126
IDS site	09/21/85	April 17	1597	April 28	1737	June 18	2582
Runacres	09/24/85	April 24	1625	April 29	1685	June 4	2283
Side Channel	09/27/85	April 4	1292	April 18	1456	June 16	2398
Mean			1488		1621		2303

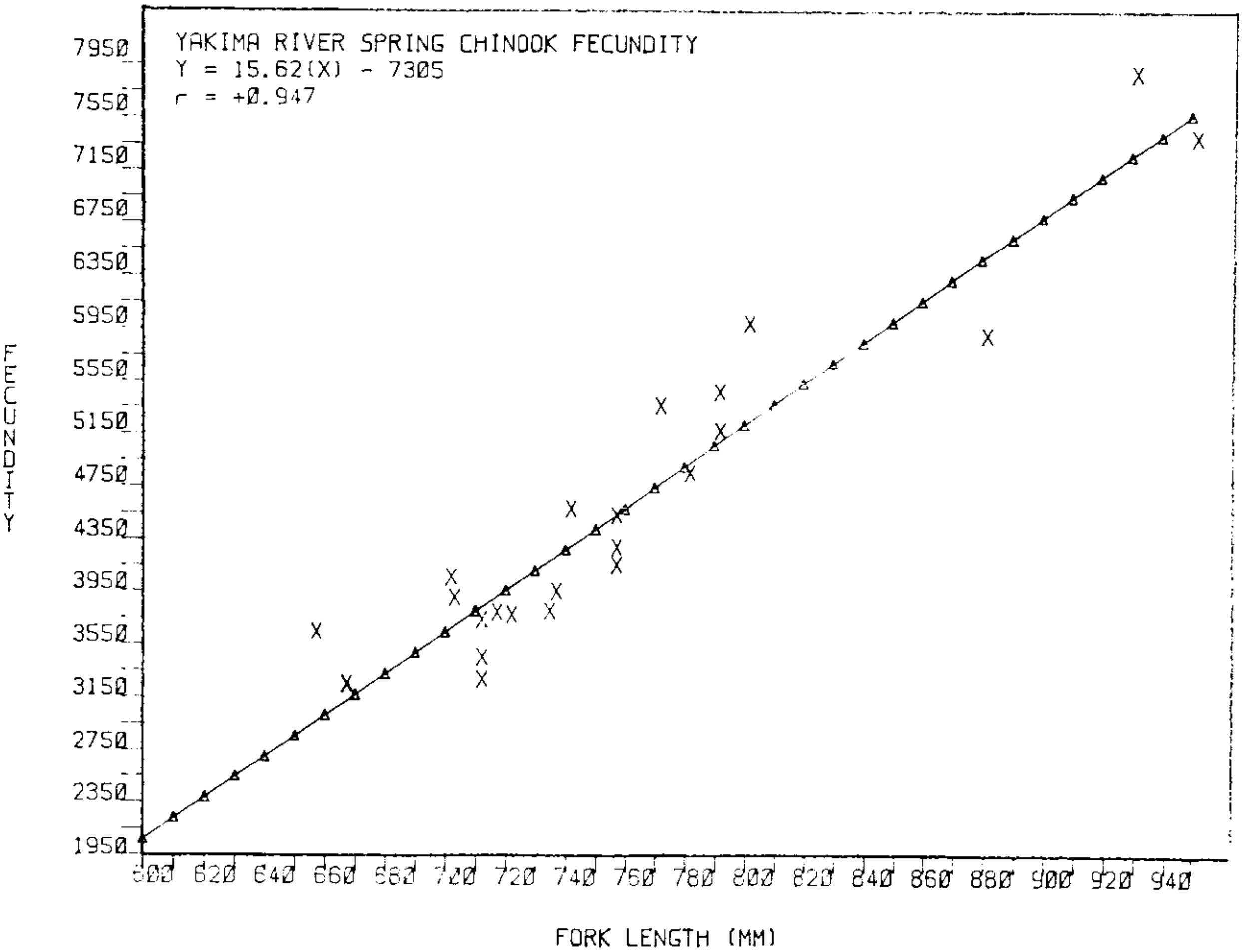


Figure 2. Length-fecundity relationship developed from 23 Yakima River spawners in 1985 and 1986.

6.1.2 DISTRIBUTION STUDIES

6.1.2.1 Seining Results

Table 7 presents the beach seining results in the Yakima River during September, 1986. Spring chinook were collected at all seining locations, with densities ranging from 0.01 fish/m^2 to 0.34 fish/m^2. Juvenile spring chinook abundance was greatest in the Yakima Canyon (RM 135). Spring chinook abundance at Cle Elum (RM 181) and Ellensburg (RM 152) was much lower. At the Cle Elum location, spring chinook were collected at only one of the five sub-sites seined, and the density was 0.02 fish/m^2. Similarly, spring chinook were collected at only two of the four sub-sites at the Ellensburg location. The mean density at these two sub-sites was 0.03 fish/m^2. The distribution pattern of spring chinook in the upper Yakima River in September is similar to what has been observed in previous years (Fast et. al., 1986), in that abundance was greatest in the Yakima Canyon, and decreased upstream to Cle Elum.

The mean fork length of spring chinook increased from Cle Elum downstream to Selah. The mean fork lengths at Cle Elum and Ellensburg were 82 mm and 84 mm, respectively. The mean fork lengths at Yakima Canyon and Selah were 93 mm and 98 mm. The increase in mean fork length from Cle Elum to Selah may be due to higher temperatures and growth rates, or possibly to a general downstream movement of larger fish.

Table 7. Density estimates for spring chinook on selected gravel bars in the Yakima River September, 1986.

Location (RM)	Density	Area seined	Fork length (mm)	
Site number	(fish/m^2)	(m^2)	$\bar{X}$ (mm)	n
Cle Elum (81)				
1	.02[a]	550	82	10
2	.00	468		
3	.00	466		
4	.00	—		
5	.00	400		
Ellensburg (152)				
1	.01[a]	350	80	20
2	.00	500		
3	.00	468		
4	.05[a]	525	88	18
Yakima Canyon (135)				
1	.09 (.07-.15)	1,320	91	118
2	.34 (.31-.38)	392	94	131
3	.02 (.02)	750	—	
4	.03 (.03-.04)	1,650	93	55
5	.01 (.01)	720	101	8
Selah (118)				
1	.01 (.01)	861	98	8
2	.00	—		
3	.02 (.01-.02)	768	97	12
4	.02 (.01-.02)	616	98	10
5	.06 (.05-.06)	1,584	98	91

[a]Confidence intervals not available.

6.1.2.2 Electroshocking Surveys

Electroshocking surveys were conducted in several previously unexamined tributaries in the Naches and Yakima River systems. Results are presented in Table 8. In the Naches system spring chinook were captured in Quartz, Milk, Cowiche, and Little Rattlesnake Creeks, as well as a side channel of the Naches River. Density estimates were 0.02 fish/m^2, 0.06 fish/m^2, 0.01 fish/m^2, 0.03 fish/m^2, and 0.25 fish/m^2, respectively. Thorton and Taneum Creeks were surveyed in the Yakima system. Spring chinook were not found in upper Taneum Creek, although spring chinook were observed in lower Taneum Creek in 1985 (Fast et. al., 1986). Spring chinook density in Thorton Creek was 0.35 fish/m^2.

Thorton Creek has one of the highest densities of any of the tributaries surveyed thus far. However the tributary has an impassable man-made barrier approximately 0.25 miles upstream from its confluence with the Yakima, limiting the amount of accessable habitat. It is believed that spawning occurs in the mainstem Yakima, and that fry move into tributaries to rear. The one exception to this might be the side channel to the Naches River, where some spawning may take place.

Table 8. Summary of electroshocking data for spring chinook in the Yakima and Naches River systems, summer 1986.

Location	Date	Pop. est.	Chinook density	$\bar{X}$(mm)
Little Naches River				
Bear Creek	7-31	0		
North Fork	7-15	0		
Crow Creek	7-17	0		
Middle Fork	7-23	0		
Pile-Up Creek	7-24	0		
Jungle Creek	7-28	0		
Quartz Creek	7-12	1	.01	
		(1)	(.01)	
American River				
Masatchee Creek	7-08	0		
Kettle Creek	7-21	0		
Union Creek	7-14	0		
Naches River				
Side channel RM 41	9-03	88	.25	67
		(82-103)	(.23-.29)	
Rock Creek	7-22	0		
Milk Creek	8-04	22[a]	.06[a]	75
Lost Creek	7-16	0		
		(1)		
Rattlesnake River				
Little Rattlesnake	7-23	1[a]	.01[a]	
Yakima River				
Thorton Creek	8-28	87	2.35	78
		(77-119)	(.31-.49)	
Tanuem Creek	8-05	0		
Cowiche Cr. (upper)	7-29	0		
Cowiche Cr. (lower)	7-28	23	.03	85
		(18-32)	(.02-.04)	

[a]Confidence intervals not available.

6.1.3 PROSSER SMOLT TRAP

Smolt outmigration was estimated from a logistic relationship between percent river diversion and percent entrainment (Fast et. al., 1985). A new logistic relationship was fit to data from test releases made in 1984, 1985 and 1986. This relationship was used to estimate 1986 outmigration and to "re-estimate" outmigration for 1983-1985 (see Appendix B), (Test releases will be made throughout the duration of the project. The diversion-entrainment relationship will be refined and the outmigration of previous years re-estimated on a yearly basis.).

6.1.3.1 Winter Movement

Under a contract with the Bureau of Reclamation, winter movement of juvenile salmonids was investigated by fishing a fyke net in Chandler Canal. The net was fished from January 17, 1986 through January 19, 1986, and on February 14, 1986. Fishing time was restricted by severe icing problems and net damage. Total raw catches of juvenile salmonids are summarized in Table 9.

Table 9. Summary of fyke - net captures of salmonids in Chandler Canal January 17 through January 19, 1986 and February 14, 1986.

Fishing period	Wild chinook	Hatchery chinook	Wild steelhead	Hatchery chinook released September 1985	Hatchery chinook released September 1985
Jan 17-19	50	6	7	3	2
Feb 14	6	3	5	0	0
Total	56	9	12	3	2

The significance of these figures cannot be assessed as the capture efficiency of the net was not determined. If, however, one assumes capture efficiency was 100 percent, outmigration may be estimated from the diversion-entrainment relationship. By this procedure it was estimated that at least 450 wild chinook, 39 hatchery chinook, and 80 wild steelhead moved past Prosser Dam in four days.

The same fyke net was also fished in Chandler Canal from January 24, 1985 through February 3, 1985, and from February 13, 1985 through March 2, 1985 (Anonymous 1985). Total estimated outmigration for wild juvenile chinook and steelhead over these 29 days was 3,637 and 2,487, respectively. It therefore appears that juvenile chinook and steelhead migrate downstream in some numbers in late winter, well before the spring smolt run. If the large fall outmigration of juvenile spring chinook and steelhead observed in tributaries of the Salmon River in Idaho (Bjornn, 1971) also occurs in the Yakima system, all statistics pertaining to smolt production will have to be re-assessed. The Yakima Nation has a tentative agreement with the Bureau of Reclamation to continue operating the screens and fish by-pass on Chandler Canal after the annual maintenance period in late October until icing becomes a serious problem, perhaps well into December, 1986. The smolt trap will be operated throughout this period and the magnitude of any fall pre-smolt outmigration will be determined.

6.1.3.2 Spring Movement

Trapping at the Chandler Canal smolt trap began February 23, 1986, and continued on a 24-hour basis until July 31, 1986. From August 1 through October 15, when the canal was drained for maintenance, the trap has been run one day a week. Continuous operation was resumed November 16, when maintenance was completed. From August 1 through October 15, a total of six juvenile chinook and one juvenile steelhead was observed in eleven 24-hour sets. Analysis of data collected after November 16 is still in progress.

A total of 296,278 salmonids were counted at Prosser trap in 1986. Lengths, weights and scales were taken from random samples of all species and release groups on a daily basis. In addition 1,139 unbranded, ad-clipped hatchery spring chinook were sacrificed for coded wire tag analysis. The total catch included 108,612 wild spring chinook, 19,815 wild fall chinook, 45,441 hatchery spring chinook, 27,283 hatchery fall chinook, 50,576 wild steelhead, 13,924 hatchery steelhead, 1,576 hatchery rainbow trout and 29,051 hatchery coho (see Table 10).

6.1.3.3 Wild Chinook

Total 1986 outmigration of wild spring and fall chinook was estimated to be 169,076 and 30,212, respectively (Table 11 summarizes weekly passage in 1986, and Appendix B summarizes daily passage estimates). Outmigration for 1983-1985 was also re-estimated with the new relationship, and revised figures appear in Table 12.

Table 10. Monthly captures at Prosser Smolt Trap, 1986.

Month	Wild spring chinook	Wild fall chinook	Hatchery spring chinook	Hatchery fall chinook[a]	Wild steel-head	Hatchery steel-head[b]	Trout[c]	Hatchery coho[d]	June 1985 hatchery spring chinook[e]	Sept 1985 hatchery spring chinook[f]	Nov 1985 hatchery spring chinook[g]	June 1985 Selah wild spring chinook[h]	Fall 1985 Naches wild spring chinook[i]	Trucked 1985 hatchery[j] spring chinook	Acclimated 1985 hatchery spring chinook[l]	Native spring chinook	Hybrid spring chinook
Feb.	115	0	7	0	297	0	0	0	1	0	0	0	0	0	0	0	0
March	386	0	74	0	1,095	0	2	1	1	1	3	0	0	0	0	0	0
April	58,550	234	25,801	0	19,557	1,080	326	3,194	8	33	423	12	90	86	447	395	454
May	45,363	14,269	19,023	112	26,277	11,913	1,190	23,895	4	14	109	7	30	285	231	263	199
June	4,216	4,658	508	27,033	2,522	929	58	1,943	0	0	0	0	0	7	4	3	2
July	0	654	28	138	18	2	0	18	0	0	0	0	0	0	0	0	0
Season Total	108,612	19,815	45,441	27,283	50,576	13,924	1,576	29,051	14	48	535	19	120	378	682	661	655

[a]Hatchery fall chinook, o-age, released 5/20/86 at Sunnyside Dam.
[b]Hatchery steelhead, age-1, released 3/31/86-4/13/86 on volitional basis from Nelson Springs (near confluence of Naches and Yakima Rivers). All were adipose-clipped.
[c]*Salmo gairdneri* with crumpled dorsal, intact adipose, "non-smolty" appearance.
[d]Hatchery coho allowed volitional release starting 3/31/86 from Nile Springs (Rm 29, Naches River).
[e]Hatchery spring chinook, 0-age fry scatter planted 6/4/85 in upper Yakima River median release point RM 165.
[f]Hatchery spring chinook, 0-age parr scatter planted 9/18/85-9/19/85 in upper Yakima River median release point RM 165.
[g]Hatchery spring chinook 0-age par scatter-planted 11/19/85-11/20/85 in upper Yakima River median release point RM 165.
[h]Wild spring chinook captured branded and released 6/13/85-6/14/85 in Yakima River near Selah (RM 120).
[i]Wild spring chinook migrating out of the Naches River captured, branded, and released at Wapatox smolt trap (RM 17.1, Naches River) September through November, 1985.
[j]Hatchery spring chinook, age- 1 scatter-planted (without acclimation) in upper Yakima River 4/19/86 and 4/28/86, median release point RM 165.
[k]Hatchery spring chinook, age-1, acclimated up to 3 weeks in pond at RM 190, Yakima River. Volitional release began 3/27/86.
[l]Hatchery-reared age-1 spring chinook spawned from wild Yakima River adults. Acclimated up to 3 weeks in pond at RM 192, Yakima River. Volitional release began 3/27/86.
[m]Hatchery-reared age-1 spring chinook spawned from wild Yakima River males and Leavenworth NFH females. Acclimated up to 3 weeks in pond at RM 192, Yakima River. Volitional release began 03/27/86.

Table 11. Outmigration for 1986, Prosser smolt trap (uncorrected for intra-canal mortality).

DATES	WILD SPRING CHINOOK	WILD FALL CHINOOK	HATCH. SPRING CHINOOK	HATCH. FALL CHINOOK	WILD STEEL HEAD	HATCH. STEEL HEAD	TROUT	HATCH. COHO	JUNE'85 CHINOOK FRY	SEP.'85 CHINOOK PARR	NOV.'85 CHINOOK PARR	SELAH JUNE '85 PARR	FALL WAPATOX PARR	TRUCK'86 CHINOOK SMOLTS	POND '86 CHINOOK SMOLTS	NATIVE YAKIMA SMOLTS	HYBRID CHINOOK SMOLTS
2/23-2/28	1000	0	84	0	4069	0	0	0	5	0	0	0	0	0	0	0	0
SUBTOTAL	1000	0	84	0	4069	0	0	0	5	0	0	0	0	0	0	0	0
3/1---3/7	637	0	96	0	11018	0	0	0	0	0	0	0	0	0	0	0	0
3/8---3/14	580	0	18	0	6684	0	0	0	0	0	0	0	0	0	0	0	0
3/15-3/21	348	0	46	0	1654	0	0	6	0	6	17	0	0	0	0	0	0
3/22-3/31	1447	0	357	0	3912	0	12	0	5	0	6	0	0	0	0	0	0
SUBTOTAL	3012	0	517	0	23268	0	12	6	5	6	23	0	0	0	0	0	0
4/1---4/7	4245	5	2362	0	6739	16	162	199	5	0	63	0	18	5	69	44	34
4/8---4/14	33577	26	12735	0	15055	305	263	284	3	23	289	9	50	3	153	214	198
4/15-4/21	8678	0	4094	0	4333	139	88	532	3	5	67	4	10	2	70	103	79
4/22-4/30	50932	278	22675	0	12448	1007	166	3239	4	27	334	6	72	102	410	295	402
SUBTOTAL	97432	309	41866	0	38575	1467	679	4254	15	55	753	19	150	112	702	656	713
5/1---5/7	20778	532	7377	1	8593	1299	106	3716	5	6	79	4	21	51	135	129	109
5/8---5/14	12559	1005	5921	0	7008	4153	211	4989	0	4	30	2	11	87	68	71	79
5/15-5/21	4365	2112	2075	0	5936	2450	475	2836	0	2	9	0	1	51	21	35	25
5/22-5/31	22620	18582	9309	242	13159	8693	850	24915	0	3	13	1	2	191	54	97	31
SUBTOTAL	60322	22231	24682	243	34696	16595	1642	36456	5	15	131	7	35	380	278	332	244
6/1---6/7	5556	3697	980	6759	2541	1410	53	2210	0	0	0	0	0	16	6	4	2
6/8--6/14	1027	1233	51	15827	831	177	28	546	0	0	0	0	0	0	1	1	0
6/15-6/21	476	1201	7	5170	294	31	3	204	0	0	0	0	0	0	0	0	0
6/22-6/30	251	804	11	3947	56	7	0	38	0	0	0	0	0	0	0	0	0
SUBTOTAL	7310	6935	1049	31703	3722	1625	84	2998	0	0	0	0	0	16	7	5	2
7/1---7/7	0	346	16	135	16	1	0	11	0	0	0	0	0	0	0	0	0
7/8--7/14	0	163	4	23	0	1	0	1	0	0	0	0	0	0	0	0	0
7/15-7/21	0	149	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0
7/22-7/31	0	80	0	0	3	0	0	2	0	0	0	0	0	0	0	0	0
SUBTOTAL	0	738	30	158	19	2	0	19	0	0	0	0	0	0	0	0	0
SEASON	169076	30213	68228	32104	104349	19689	2417	43733	30	76	907	26	185	508	987	993	959

Table 12. Estimated outmigration of wild salmonid smolts at Prosser Dam, 1983-1986, and estimated egg-to smolt survival for wild spring chinook. (Uncorrected for intra-canal mortality.)

Year	Wild spring chinook	Egg-to-smolt survival wild spring chinook	Wild fall chinook	Wild steelhead
1986	169,077	4.59	30,212	104,349
1985	83,614	4.47	60,186	55,027
1984	123,732	4.89	33,400	65,971
1983	136,102	6.45	87,178	58,241

It should be noted that the figures in Table 12 implicitly assume all smolts entering the canal survive passage through it. In light of the results of releases of branded smolts into the canal, this assumption is highly improbable (see Appendix B.). Seber (1982) developed a formula to estimate natural mortality for a system subject to natural and fishing mortality, both of which occur at an exponential rate. If one assumes that "unhandled" fish suffer the same intra-canal mortality as branded fish released at night (when virtually all smolt movement occurs) then, allowing recaptures of marked fish to take the place of "fishing mortality," it is possible to use Seber's formula to estimate the instantaneous rate of natural mortality in the canal, M. Release data from 1984-1986 allow estimation of a mean M for April and May of 0.0828 and 0.1370, respectively.

If one further assumes that all unhandled migrants traverse the canal in one day (24 hours) and that canal mortality is constant from March through April and from May through July, outmigration to Prosser Dam can be corrected for in-canal losses by dividing the appropriate monthly estimates by the survival rate for canal passage , e^{-M}. A summary of seasonal catches of wild salmonids adjusted in this manner appears in Table 13.

Table 13. Estimated total outmigration of wild juvenile salmonids to Prosser Dam in the years 1983-1986, and estimated egg-to-smolt survival rates for wild spring chinook. Estimates have been adjusted for losses during canal passage.

Year	Wild spring chinook	Egg-to-smolt survival, wild spring chinook (percent)	Wild fall chinook	Wild steelhead
1986	187,824	5.10	34,656	115,717
1985	92,545	4.95	68,928	61,829
1984	138,649	5.48	38,332	74,123
1983	150,555	7.13	99,938	65,368

It is unlikely that all of the assumptions entailed by the estimates in Table 13 are met. Therefore these figures should be regarded as a rough upper estimate of the degree to which outmigration may have been underestimated because of undetected losses associated with canal transit. The figures in Table 13 are roughly ten percent larger that the unadjusted figures in Table 12. True figures are probably somewhere in between, because the trans-canal survival of unhandled migrants can be neither 100 percent nor so low as in fish subject to the stress and disorientation of handling.

Until it becomes possible to estimate intra-canal losses of unhandled fish more precisely, the unadjusted figures in Table 12 are the most accurate available and will be the ones employed in calculating other statistics.

A outmigration of 169,076 spring chinook smolts in 1986 is consistent with with brood year (1984) escapement and the low flows that occurred in the Yakima River during April and May. Estimated egg deposition in 1984 was 3,686,128 (Fast et. al., 1985). Table 14 illustrates that mean monthly discharge in April and May at Prosser and Sunnyside Dam was comparable in 1984, 1985 and 1986, and was substantially higher in 1983. The mean estimated egg-to-smolt survival for 1984 and 1985 is 4.68 percent, a rate which would predict a 1986 run of 172,510, just two percent greater that was actually observed. If egg-to-smolt survival in 1987 approximates 1984-1986, the 5,198,408 eggs deposited in 1985 will produce about 240,000 smolts. Alternatively, if the survival rate approximates the 1983 rate of 6.45%, a run of about 335,000 will occur. The decreased outmigration of fall chinook and the dramatic increase in outmigration of wild steelhead in 1986 may both be attributable to the same factor, a late February-early March flood in Satus and Toppenish Creeks. Electroshocking surveys and fyke-netting operations have demonstrated that most production of steelhead and fall chinook above Prosser Dam occurs in the drainages of Satus and Toppenish Creeks. In the last week of February and the first two weeks of March an early runoff caused both creeks to flood, with Satus Creek cresting at 2,135 cfs on February 24 and Toppenish at 2,002 cfs on February 28. It is probable that this flood "flushed" steelhead pre-smolts from both

Table 14. Mean monthly discharge in the middle reaches of the Yakima River during the spring chinook smolt run of 1983, 1984, 1985 and 1986.

River section and year		March mean discharge (cfs)	April mean discharge (cfs)	May mean discharge (cfs)	June mean discharge (cfs)
Yakima	1986	3430	1895	1821	3088
Canyon[a]	1985	1182	2993	2834	3146
(RM 140)	1984	2673	2499	3974	5775
	1983	3488	3339	4752	3641
Sunnyside[b]	1986	7837	1965	863	674
(RM 103.8)	1985	1696	2774	1293	991
	1984	4248	2139	2669	6119
	1983	6671	4092	5442	3404
Prosser	1986	9049	3049	2248	2023
(RM 47.1)	1985	2224	3776	2602	2397
	1984	5036	3690	4172	6963
	1983	9488	6163	6990	5542

[a]Gauging station in middle of major spring chinook rearing area.
[b]Gauging station at Sunnyside Dam, a site intermittently subject to very low flows and possibly high predatory mortality.

creeks, augmenting the 1986 outmigration with fish that would otherwise have left in 1987. It is also possible that floodwaters killed some pre-emmergent fall chinook by smothering them under sediments or subjecting them to physical trauma associated with bedload movement, and flushed other emergent fry from the system when they were too small to be retained in the trap at Chandler.

6.1.3.4 Distinguishing Spring from Fall Chinook

Length frequencies and scale analyses were used to differentiate spring and fall chinook outmigrants. Monthly length frequencies of wild chinook sampled in 1986 are depicted in

Figures 3 and 4. Lengths are bimodally distributed in May and June, and increase abruptly in March.

An analysis of scales taken from 1983 through 1986 indicated that the smaller mode of bimodal length frequencies represented mostly fall chinook. Therefore, fall chinook were discriminated from spring chinook on the basis of a combination of scale and length frequency data. Explicitly, the number of wild fall chinook migrating past Prosser Dam in a given week was estimated as follows:

$$N_j \sum_{i=a}^{i=b} \left[(L_{i,j}) \ (F_{i,j}) \right] = N_{f,j} \qquad \text{equation 1.}$$

where a and b are length increment bounds, with "a" representing "less that 40 mm,", "b" representing "greater than 199 mm", and with intervening steps of 5 mm—(40-44,45-49,...,195-199);

$L_{i,j}$ = the percent of sampled wild chinook in week j falling in length interval i ;

$F_{i,j}$ = the percent of fish in length interval i in week j determined from scale analysis to be fall chinook, i.e., 0-age;

N_j = the estimated outmigration of all wild chinook in week j ; and

$N_{f,j}$ = the estimated number of wild fall chinook in week j.

Monthly trends in mean length, weight and condition factor for wild spring and fall chinook from 1983 to 1986 are summarized

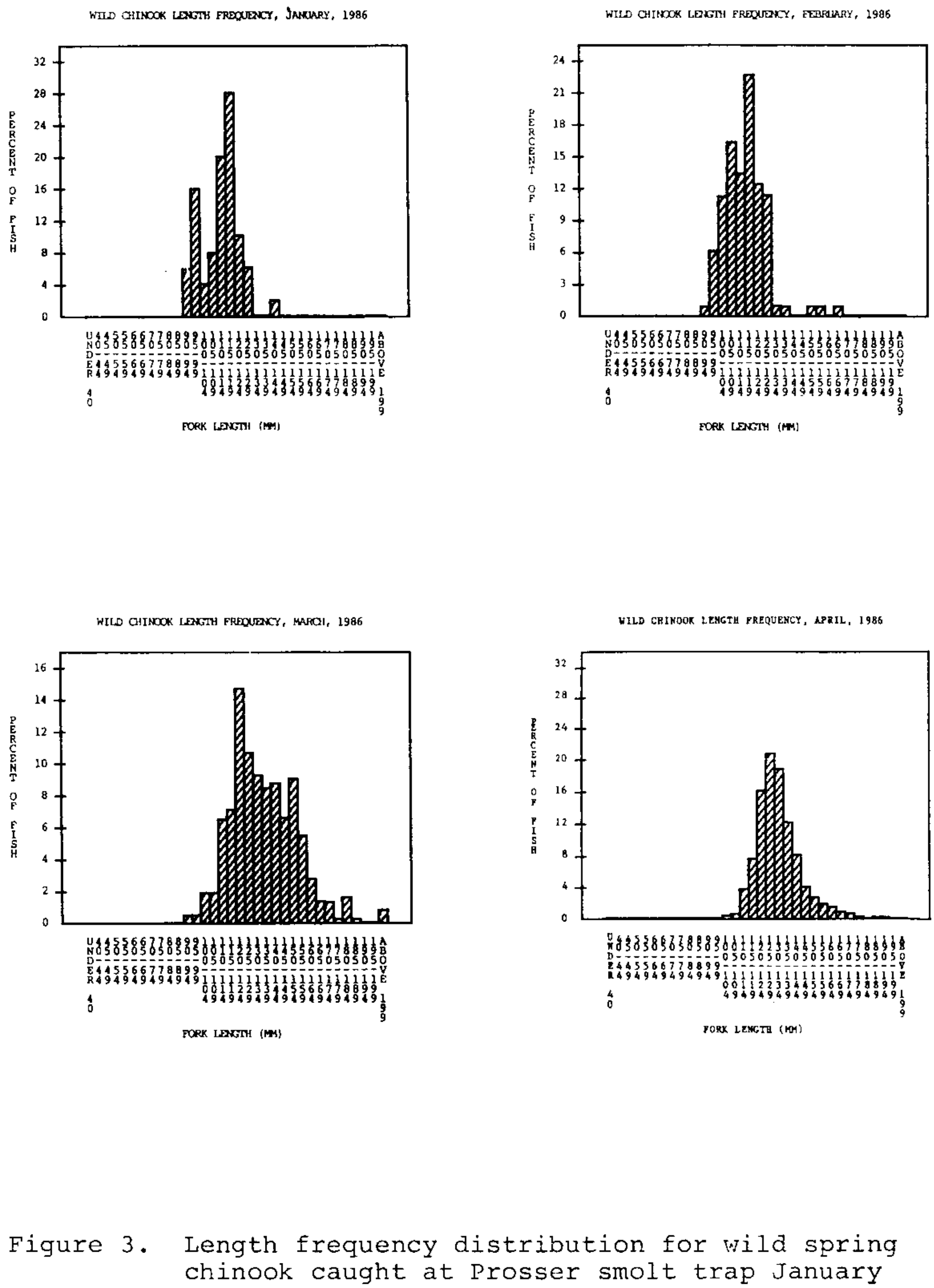
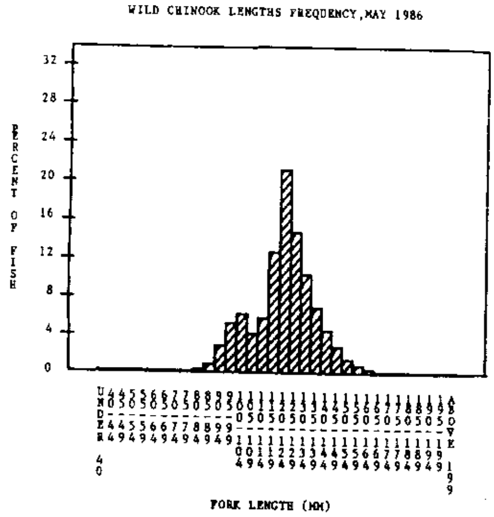
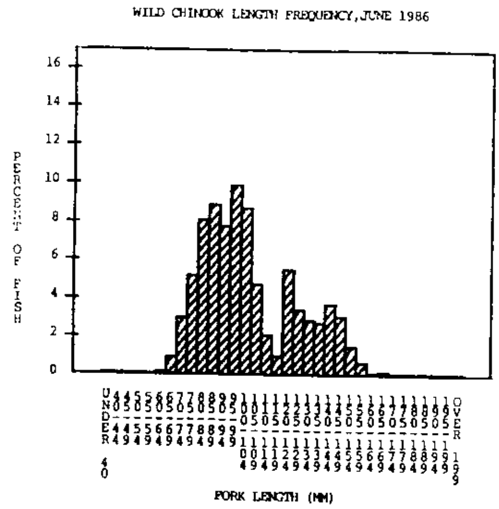


Figure 3. Length frequency distribution for wild spring chinook caught at Prosser smolt trap January through April, 1986.





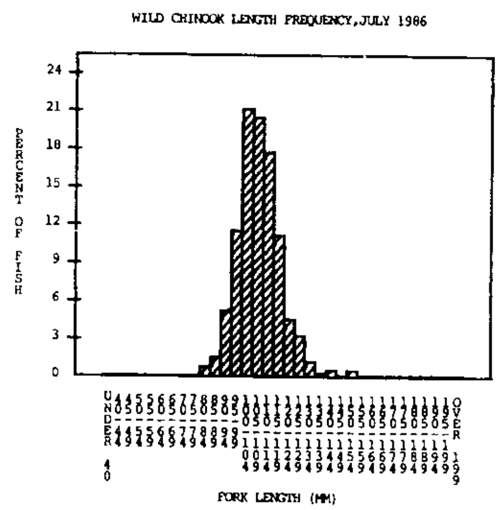


Figure 4. Length frequency distribution for wild spring chinook caught at Prosser smolt trap May through July, 1986.

in Table 15. The increase in mean length of wild chinook in March relative to January and February for both 1985 and 1986 cannot be attributed to growth, as winter conditions prevail throughout most of March. Rather it would seem more likely that a different, larger-sized run of fish, probably smolts, began to move by Prosser in March. Table 15 also indicates that the mean length and weight of spring chinook outmigrants is inversely related to run size, perhaps reflecting competition. Indeed a ranking of the weights of wild spring chinook in April and May (for which the data is complete from 1983-1986) is the exact inverse of run size ranking (Table 16). The 1986 spring chinook smolt run was earlier and more compressed temporally than in any year since 1983. Although counting at Prosser smolt trap began on a different date every year, dates of quartile passage are changed very little when cumulative passage figures are adjusted for different starting dates (Table 17 and Figure 5). Two statistical tests were performed on the temporal distributions of outmigrants in the years 1983 through 1986-- a chi-square test of homogeneity and a series of Kolmogorov-Smirnov (KS) tests of goodness of fit between seasonal recapture distributions. Outmigrants prior to April 4 were ignored to make all distributions comparable. A chi-square test of the temporal distribution of outmigration in 1983 through 1986 showed that outmigration was not distributed homogenously through the season in the last four years, and the KS tests showed the temporal distributions of outmigration were all significantly different from one another. The 1986 fall chinook smolt run began later and ended earlier than in previous years

Table 15. Monthly mean length and weight statistics for wild spring and fall chinook captured January through July in 1983, 1984 1985 and 1986 at Prosser Smolt Trap.

Year	January fork length (mm)	January weight (gm)	January condition factor[a]	February fork length (mm)	February weight (gm)	February condition factor[a]	March fork length (mm)	March weight (gm)	March condition factor[a]	April fork length (mm)	April weight (gm)	April condition factor[a]	May fork length (mm)	May weight (gm)	May condition factor[a]	June fork length (mm)	June weight (gm)	June condition factor[a]	July fork length (mm)	July weight (gm)	July condition factor[a]
Spring chinook																					
1986	111	nd	nd	115	15.8	10.7	135	33.0	12.3	129	22.8	10.6	126	22.2	10.6	127	23.0	10.8	-d	-d	-d
1985	122[a]	nd	nd	122[b]	nd	nd	156	44.1	11.0	139	30.1	10.7	126	22.0	10.2	134	33.3	10.7	-d	-d	-d
1984	nd	nd	nd	nd	nd	nd	134	26.3	10.8	133	25.8	10.8	135	25.9	10.3	140	32.4	10.7	-d	-d	-d
1983	nd	nd	nd	nd	nd	nd	-c	-c	-c	129	24.5	11.1	126	24.2	11.0	127	nd	nd	-d	-d	-d
Fall chinook																					
1986	-e	-e	-e	-e	-e	-e	-e	-e	-e	86	6.5	11.2	99	11.4	11.5	90	9.0	12.6	106	nd	nd
1985	-e	-e	-e	-e	-e	-e	-e	-e	-e	79	5.6	10.8	90	8.6	10.8	86	9.0	11.4	106	18.0	15.2
1984	-e	-e	-e	-e	-e	-e	-e	-e	-e	-f	-f	-f	94	10.7	12.2	99	12.6	11.7	108	nd	nd
1983	-e	-e	-e	-e	-e	-e	-e	-e	-e	88	9.2	12.3	89	9.0	12.3	90	10.5	13.5	103	14.0	13.0

n.d. = No data available.

[a]Estimated as (W/L 3) x 1,000,000 where w = weight in grams and L = fork length in millimeters.

[b]Anonymous, 1985. January and February data were combined.

[c]Chandler Canal smolt trap not opertated in March 1983.

[d]All wild chinook captured in July classed as fall chinook.

[e]All wild chinook captured before April classed as spring chinook.

[f]No fall chinook were captured in April 1984.

Table 16. Mean weight and length of wild spring chinook smolts in April and May, and ranking of run-size and mean weight, 1983-1986.

Year	Total run	Run size rank	Mean length April-May (mm)	Mean weight April-May (gm)	Mean weight rank
1986	169,076	1st	128	22.6	4th
1983	136,102	2nd	128	24.4	3rd
1984	123,732	3rd	134	25.8	2nd
1985	83,614	4th	133	26.4	1st

Table 17. Dates of 25, 50 and 75 percent passage of wild spring chinook smolts, 1983-1986. Upper date derived from cumulative passage figures beginning on the actual date counting began. Lower date derived from cumulative passage figures beginning April 4, the latest opening date in the years 1983-1986.

Year	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage
1986	April 15 April 17	April 25 April 25	May 9 May 10
1985	April 17 April 17	April 30 April 30	May 16 May 17
1984	April 19 April 20	May 4 May 5	May 18 May 19
1983[a]	April 19 April 19	April 24 April 24	May 3 May 3

[a]Trapping began April 4, 1983; thus upper and lower date identical.

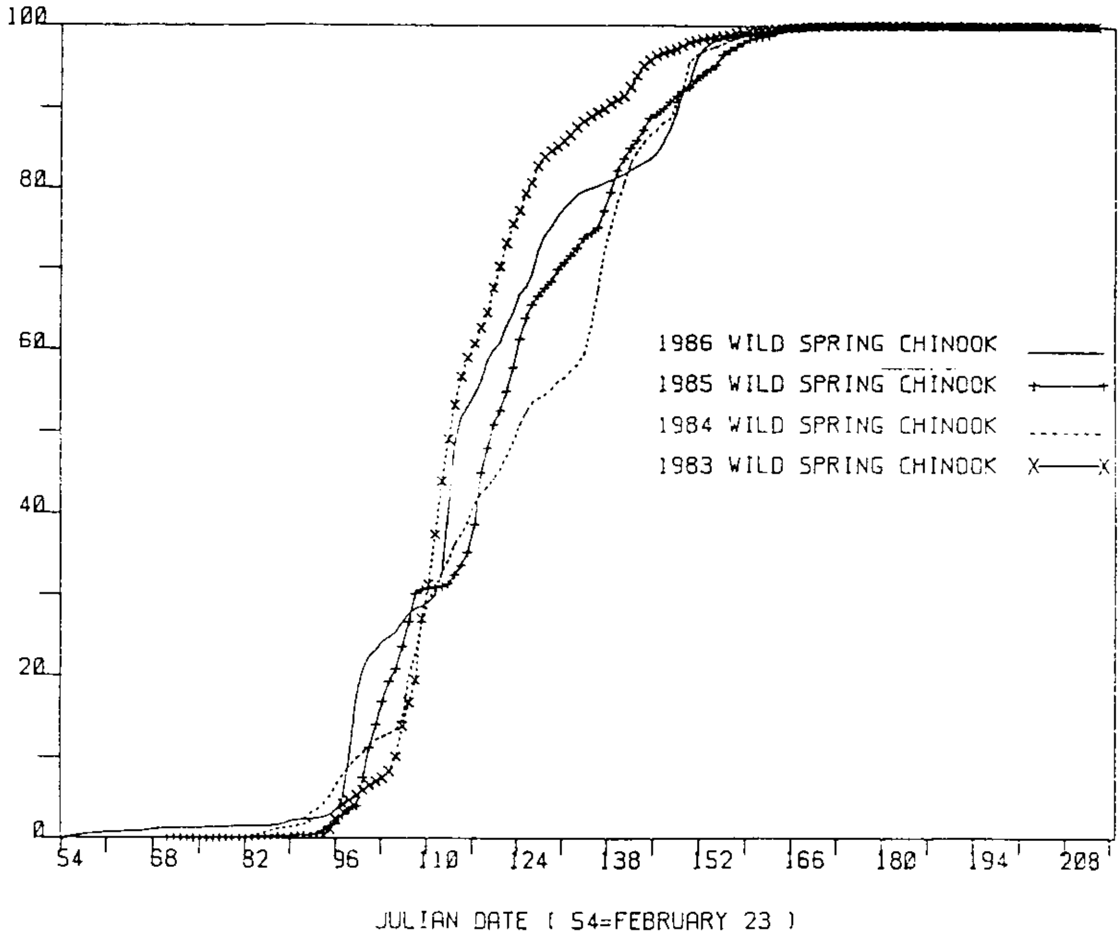


Figure 5. Cumulative percent passage of wild spring chinook smolts past Prosser Dam in 1983, 1984, 1985 and 1986.

(Table 18, Figure 6). This compression of the run may have resulted from the previously mentioned flood in Toppenish and Satus Creeks. Fry that had emerged prior to mid-March may not have been detected at the Prosser smolt trap, either because they were killed, or because they were flushed into the trap while still small enough to swim through the mesh of the net.

6.1.3.5 Wild Steelhead

Total juvenile wild steelhead outmigration was estimated at 104,349 in 1986 (Table 12). As mentioned this large increase relative to previous years may be due to a late winter flood in Satus and Toppenish Creeks which flushed a large number of pre-smolts from their rearing areas and inflated the count at Prosser.

Table 18. Revised dates of 25, 50 and 75 percent passage of wild fall chinook smolts at Prosser smolt trap, 1983-1986.

Year	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage
1986	May 26	May 29	June 1
1985	May 18	May 27	June 7
1984	May 22	May 30	June 11
1983	May 12	May 22	June 3

Two pieces of evidence support this view: the appearance of juvenile steelhead during and after the flood, and the size

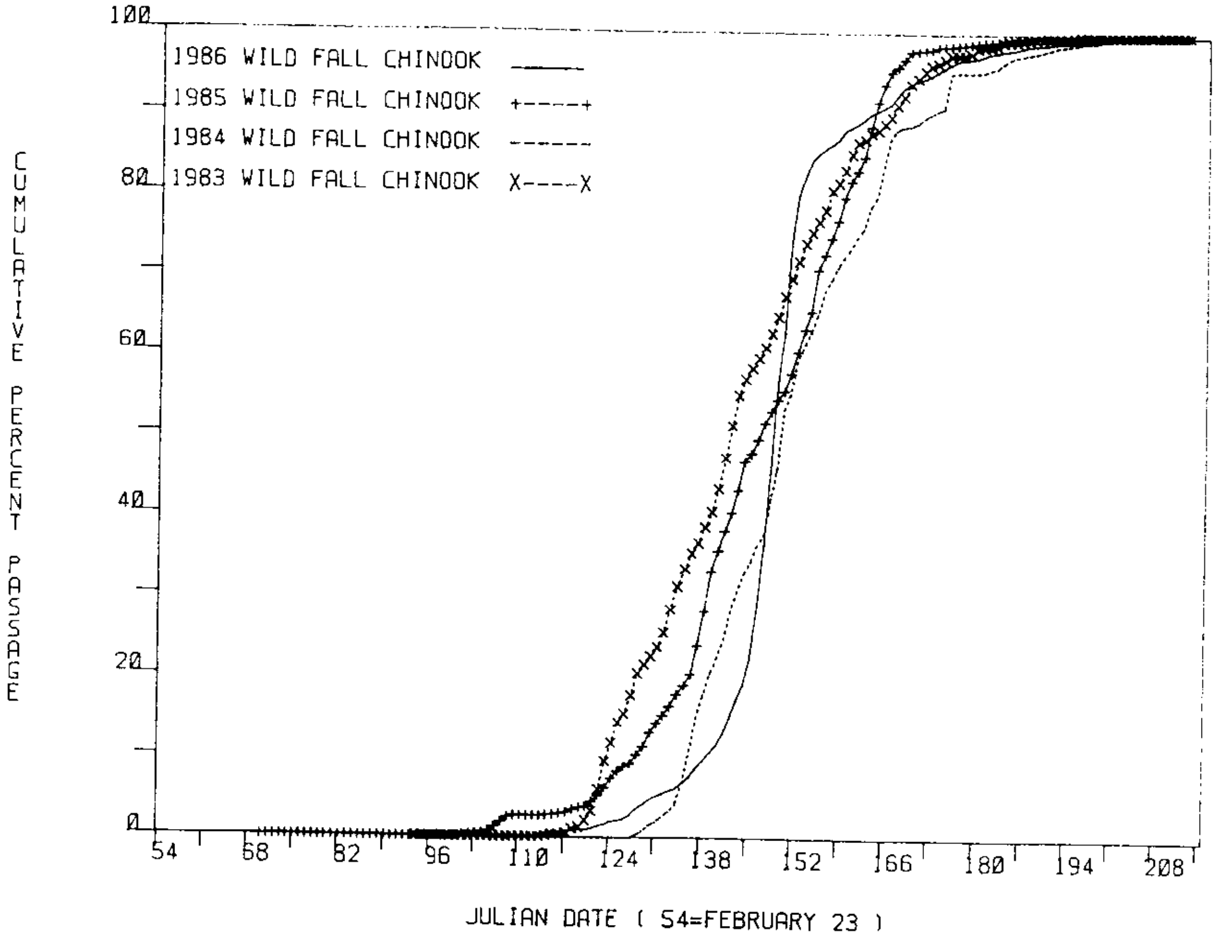


Figure 6. Cumulative percent passage of wild fall chinook smolts past Prosser Dam in 1983, 1984, 1985 and 1986.

of juvenile steelhead before and after the flood. The majority of steelhead did not acquire a typical smolt appearance until early April. Before this time many smaller fish had distinct parr marks and no silvering. Moreover, there was a sharp shift in the size distribution from smaller, parr-like steelhead during the time the flood-waters were passing Prosser, to much larger, typical smolts before and after the flood.

Floodwaters from Satus and Toppenish Creeks apparently reached Prosser Dam February 24 and the flood surge had passed by March 17 (Figure 7). The mean lengths of wild steelhead at Prosser trap during the flood surge, February 24-February 28, and March 1-March 17, were 131 and 132 mm, respectively. The mean lengths of wild steelhead from March 18-March 31 and before February 23 were 189 mm and 183 mm, respectively. Figure 8 clearly shows distinct length distributions before, during, and after the flood surge. Comparison of the two length frequency histograms for March is particularly telling as there was insufficient time for growth to have caused such a large difference: the length distribution for March 1-March 17 was significantly different from March 18-31 (X^2=618.7, 28 df), and the mean lengths for these periods were also significantly different (t = 1170, 1895 df).

Influenced by the early starting date and abnormally large catches in March, the run of wild steelhead juveniles began earlier and progressed more slowly in 1986 than in previous years (Table 19, Figure 9). Although the 1986 run was three weeks ahead

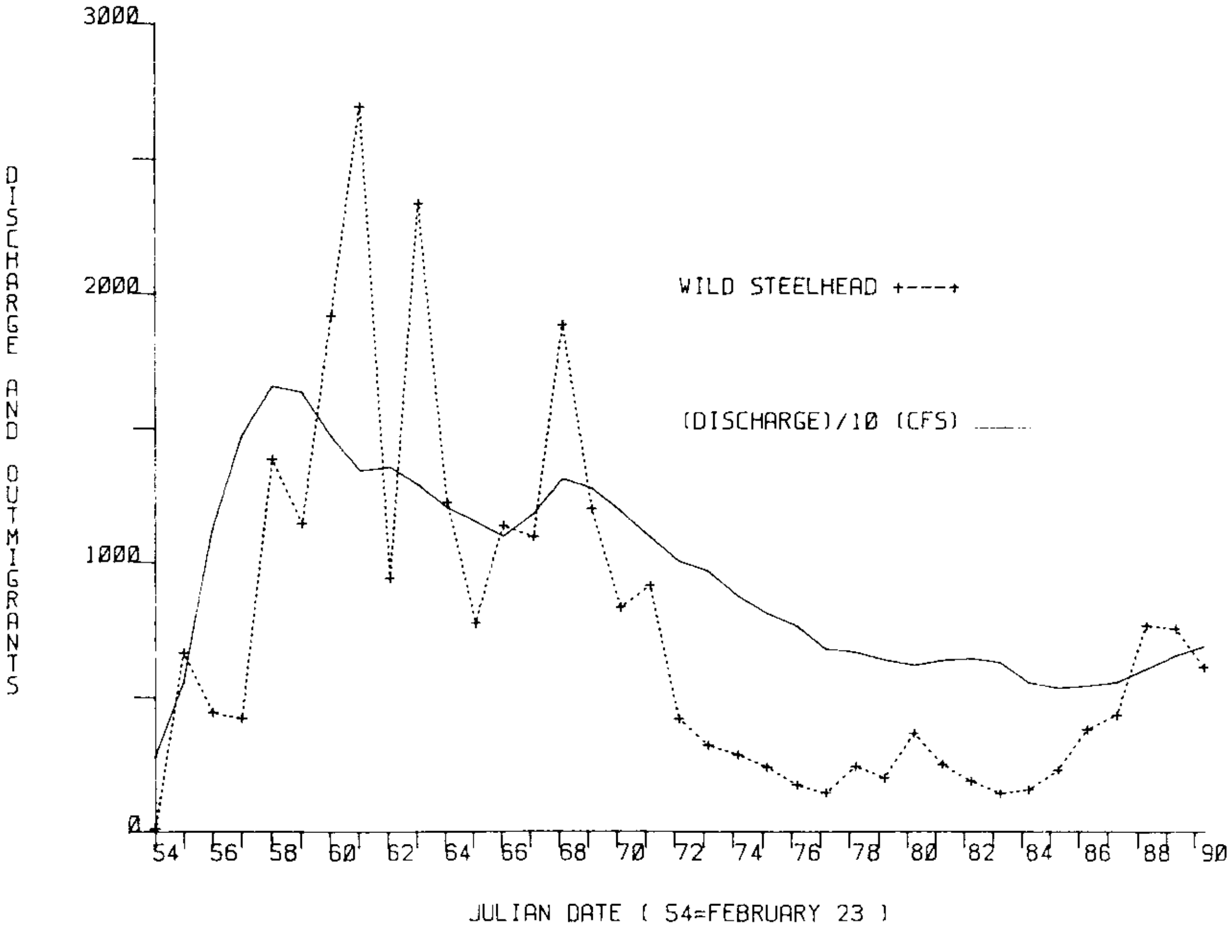


Figure 7. Mean daily discharge at Prosser Dam and estimated outmigration of juvenile steelhead from February 23, 1986, through March 31, 1986.

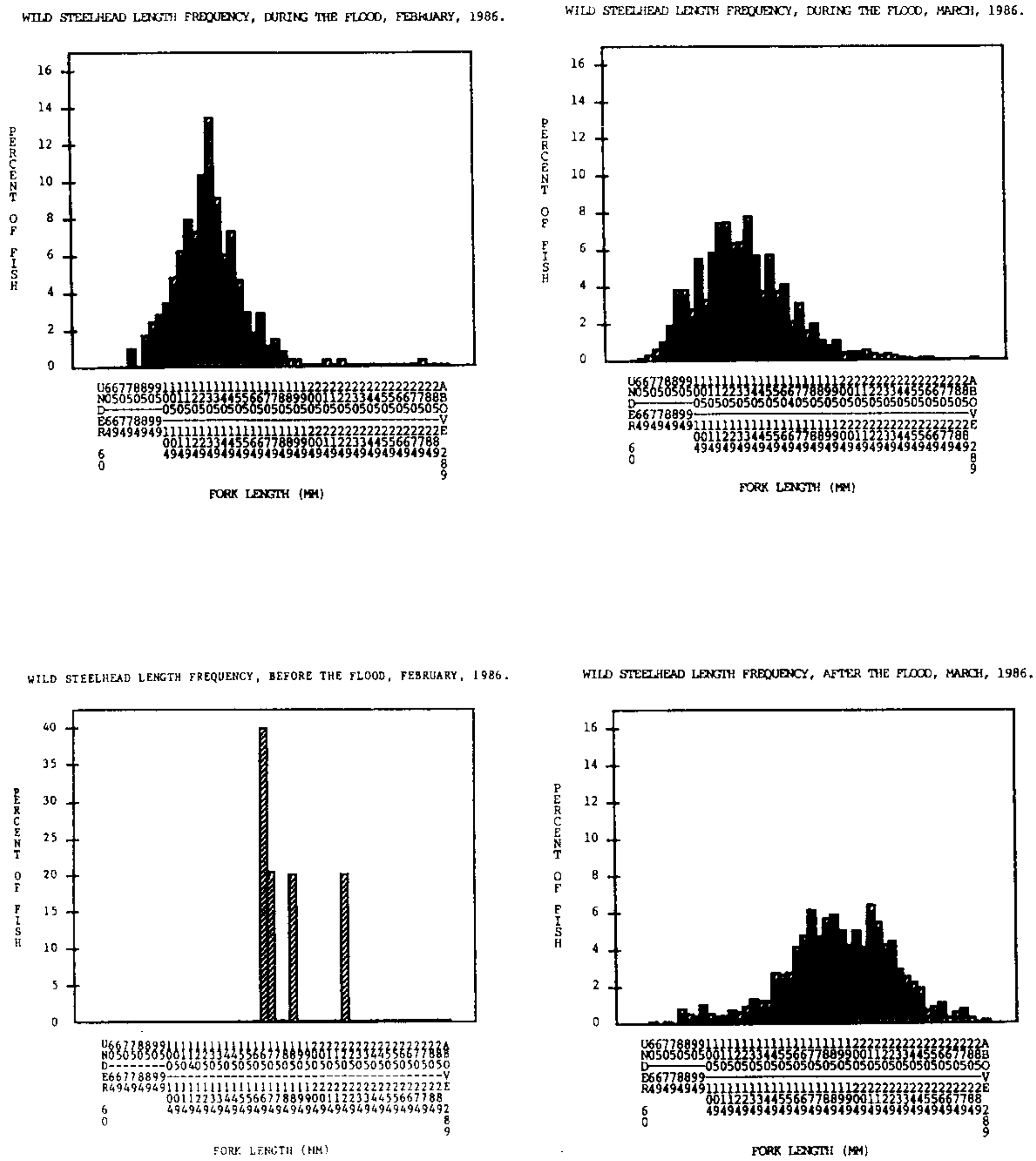


Figure 8. Length frequency histogram of wild steelhead juveniles caught in February and March, 1986, at Prosser trap.

Table 19. Dates of 25, 50 and 75, percent passage of wild steelhead juveniles, 1983-1986.

Year	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage
1986	March 30	April 20	May 11
1985	April 22	May 5	May 18
1984	April 21	May 5	May 16
1983	April 24	May 3	May 17

of earlier years at 25 percent passage, the "lead" had shrunk to one week by 75 percent.

Mean monthly lengths and weights of wild steelhead in the 1986 run were comparable to previous years except for the duration of the flood in February and March (See Table 20). Excluding the flood period, it would appear that substantially larger steelhead begin to move past Prosser in February. As with the large wild spring chinook appearing in March, the larger February steelhead probably represent early smolts whereas the smaller fish seen in January may be a mixture of smolts and pre-smolts seeking winter habitat. The earliest steelhead smolts are seen about a month before the first chinook smolts.

6.1.3.6 Fall and Winter Behavior of Wild Spring Chinook

In 1985 a number of wild spring chinook juveniles were branded and released at Wapatox trap on the Naches River and at several sites on the Yakima River near Selah. A total of

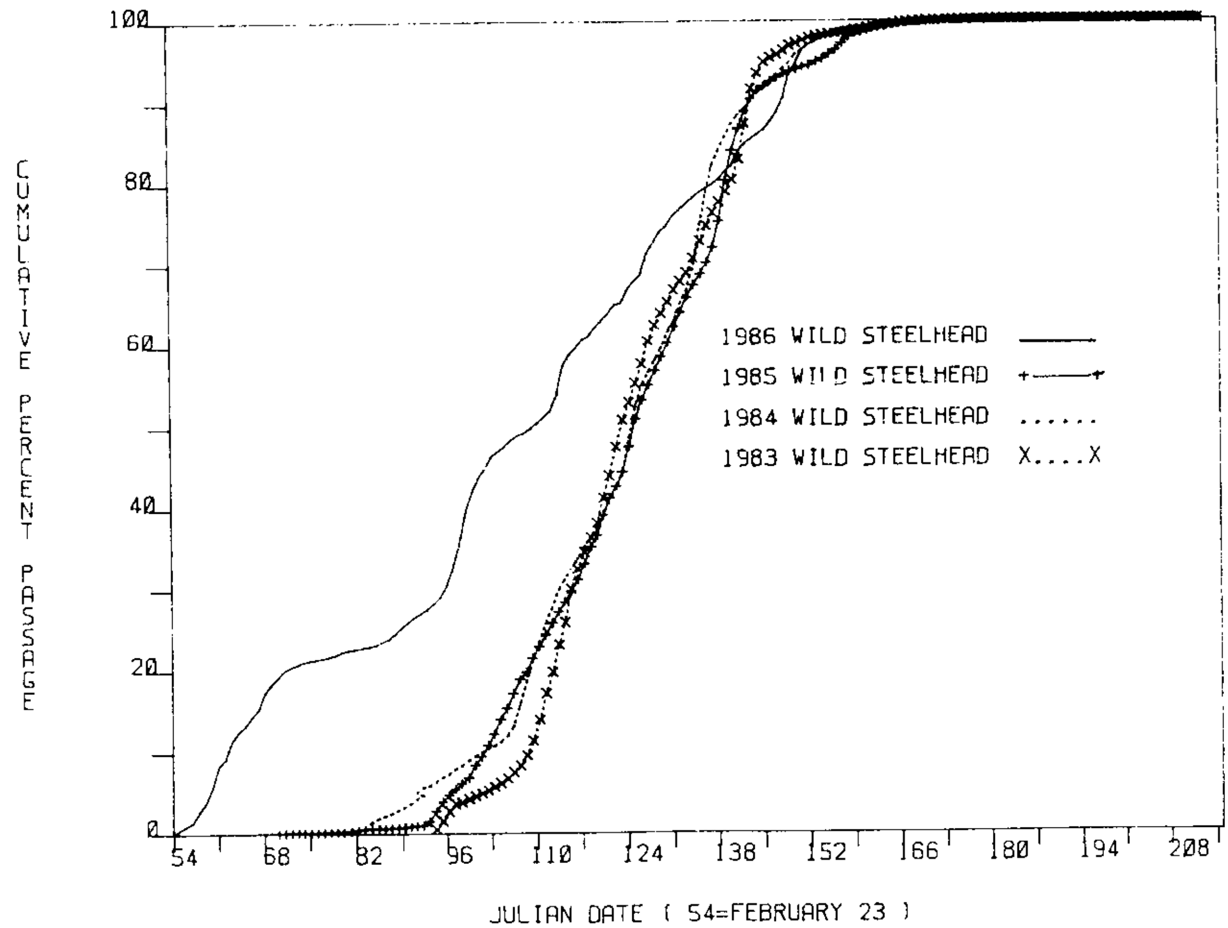


Figure 9. Cumulative percent passage of wild steelhead smolts past Prosser Dam in 1983, 1984, 1986 and 1986.

Table 20. Mean monthly length, weight, and condition factor of wild and hatchery steelhead in 1983 through 1986 and assorted statistics for hatchery steelhead 1983-1986.

	January			February			March			April			May			June		Seasonal	Migration survival (percent)	Release rate (mL/day)	Release date	Size (no./lb)
	Fork length (mm)	Weight (grams)	Condition factor	Fork length (mm)	Weight (grams)	Condition factor	Fork length (mm)	Weight (grams)	Condition factor	Fork length (mm)	Weight (grams)	Condition factor	Fork length (mm)	Weight (grams)	Condition factor	Fork length (mm)	Weight (grams)	Condition factor				
				during flood 130.6	23.9	9.95	during flood 131.8	27.0	10.3													
Wild steelhead	158.1	n.d.	n.d.	before flood 182.6	n.d.	n.d.	after flood 189.3	77.0	10.2	186.9	69.2	9.6	183.5	61.3	9.3	198.4	81.5	9.8	22.1	1.3	March 31	5.9
Hatchery steelhead	-	-	-	-	-	-	-	-	-	209.1	91.3	9.4	219.3	88.1	8.0	206.2	81.7	8.5				
Wild steelhead	123.9[a]	n.d.	n.d.	123.9[a]	n.d.	n.d.	200.1	92.7	10.1	192.7	78.7	9.4	182.1	60.1	9.4	206.4	87.9	9.5	35.8	3.4	April 8	6.0
Hatchery steelhead	-	-	-	-	-	-	-	-	-	209.3	86.3	9.1	219.4	92.5	8.7	221.8	99.6	8.8				
Wild steelhead	-	-	-	-	-	-	189.9	69.0	10.1	192.3	73.8	9.9	187.9	66.8	10.0	201.9	86.4	10.0	24.7	5.2	April 17	6.0
Hatchery steelhead	-	-	-	-	-	-	-	-	-	196.0	65.9	8.5	204.9	72.9	8.2	224.2	n.d.	n.d.				
Wild steelhead	-	-	-	-	-	-	n.d.	n.d.	n.d.	193.1	86.3	10.4	182.0	70.2	10.3	197.0	88.3	8.5	17.7	2.3	April 8	n.d.
Hatchery steelhead	-	-	-	-	-	-	-	-	-	148.1	34.9	10.9	138.0	28.9	10.6	n.d.	n.d.	n.d.				

n.d. = no data.
Condition factor = $(W/L^3) \times 1{,}000{,}000$ W=grams and L=millimeters.
[a]Anonymous, 1985. Catches for January and February were lumped.

1,267 fish were branded as they moved through Wapatox trap from September through early November, 1985. On June 13 and 14, 1985, 1800 fish were branded and released near Selah, the lowest point of spring chinook spawning. The purpose of both releases was to obtain some information on movements during the fall and winter and on pre-smolt survival.

A total of 185 (14.5%) of the Wapatox fish, and 25 (1.4%) of the Selah fish migrated to Prosser in 1986. The 14.5 percent of the Wapatox fish that migrated to Prosser is comparable to the survival rates of hatchery-reared smolts released in the upper Yakima in the spring of 1986 (survival ranged from 8.0 to 18.9 percent; see section 6.1.3.7.1). It is therefore plausible that most of the spring chinook juveniles that left the Naches River in the fall of 1985 over-wintered in the Yakima River above Prosser Dam. These fish then smolted at the usual time in 1986, and the losses they suffered en route to Prosser Dam were comparable to those of hatchery smolts released in the upper Yakima.

The low "survival rate" of Selah fish in 1986 may simply reflect the fact that the Yakima River at Selah is a poor rearing environment. It is conceivable that the middle Yakima River, from Selah to the confluence of the Naches, provides good habitat for over-wintering, but poor habitat for summer rearing; and that most chinook forced to rear in this area are lost.

6.1.3.7 Hatchery Releases

All hatchery chinook in 1986 were ad-clipped and coded wire tagged, and about ten percent were freeze-branded. In 1986, for the first time, survival to Prosser was monitored both by counting freeze-brands and by reading coded wire tags extracted from sacrificed fish. Tag analysis will indicate whether freeze brands fade away over time and will provide a second estimate of group survival. A total of 1,139 coded wire tags were taken from unbranded, ad-clipped hatchery chinook in 1986. As of this writing not all of the tags have been read. Results from tag analysis will be reported in the 1987 Annual Report.

Hatchery steelhead and hatchery coho were not freeze-branded, but the hatchery steelhead were readily identifiable by ad-clips and general appearance. The population of wild coho in the Yakima River is negligible so all coho were assumed to be hatchery fish.

6.1.3.7.1 Effect of Acclimation and Volitional Release on Survival.

Mary's pond on the Yakima River (RM 192) was used to acclimate the 1986 smolt releases, and the same 12 sites on the upper Yakima (median release point RM 165.1) used since 1983 were the release sites for non-acclimated fish. Three groups of spring chinook were acclimated in 1986: Leavenworth National Fish Hatchery (LNFH) smolts, "hybrid" smolts (progency of LNFH females and native Yakima males) and hatchery-reared native smolts. Only LNFH hatchery smolts were used in the non-acclimated group.

Acclimated groups were moved to Mary's pond over the period March 26 through March 28. It was intended they be allowed volitional release about two weeks later, when the non-acclimated group was also to be released. However, due to a hole chewed in the block-net by a beaver also residing in the pond, release occurred considerably earlier than planned. A small hole had been chewed in the net the night of March 27, and had been repaired by the afternoon of March 28, when the last of the acclimated fish were unloaded. Shortly thereafter, the beaver apparently chewed another hole in the net, as branded fish from acclimated groups began appearing at Prosser April 1. Because it is unlikely smolts could have covered the distance from Mary's Pond to Prosser in less time, it has been assumed release occurred the night of March 28.

The escape of the acclimated groups was not detected until the first week of April, and there was thus no chance for a simultaneous release of non-acclimated fish. One of two raceways of non-acclimated fish was released at the usual sites on April 9. The other raceway was not planted until April 28 because IHN was incorrectly detected and the fish had to be re-tested before release was permitted.

A total of 50,657 non-acclimated hatchery spring chinook ("trucked fish"), of which 6,383 were branded, were released in 1986. Release figures for acclimated LNFH smolts ("pond fish"), hybrid smolts and native smolts were 51,846 (5910 branded), 46,476 (5,438 branded) and 33,052 (5,255 branded). Based on recoveries of branded fish at Prosser, percent survival for trucked, pond, hybrid and native smolts was 8.0, 16.7, 17.6 and 18.9 percent (see Table 21).

Run timing for all acclimated groups in 1986 was quite similar and, as expected, was well ahead of the non-acclimated group (Table 22 and Figures 10 through 13). As all acclimated

Table 21. Revised outmigration and survival estimates for acclimated and non-acclimated hatchery chinook smolts for 1983 through 1986, and for hybrid and native chinook smolts in 1986.

Year	Released group	Number branded fish released	Estimated number of branded fish migrating to Prosser	Percent survival
1986	Truck	6,383	508	8.0
	Pond	5,910	987	16.7
	Hybrid	5,438	959	17.6
	Native	5,255	993	18.9
1985	Truck	8,225	899	23.4
	Pond	9,905	1,236	20.4
1984	Truck	6,818	2,380	34.9
	Pond	4,653	2,703	58.1
1983	Truck	3,841	1,699	20.6
	Pond	6,056	3,815	38.5

groups had identical dates of median passage, all had the same migration rate - 5.4 mi/day. The migration rate of 4.5 mi/day attributed to the trucked group is based on a median release date and and median release site, and therefore has questionable significance. It is clear, however, that the trucked group passed by Prosser about three weeks after the acclimated groups, and that it took roughly a week longer for the middle 50 percent (first

Table 12. Revised run timing for hatchery spring chinook releases, 1983-86.

Year of recapture	Group	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage	Median migration rate (mi/day)	Time elapsed between passage of 1st & 3rd quartile	Release date	Survival rate (percent)
1986	Trucked smolts	May 2	May 14	May 27	4.5[a]	25	April 18	8.0
	Pond smolts	April 16	April 24	May 1	5.4	15	March 28	16.7
	Native smolts	April 14	April 24	May 4	5.4	20	March 28	18.9
	Hybrid smolts	April 15	April 24	May 1	5.4	16	March 28	17.6
	Fry released June, 1985	April 3	April 10	April 23	-	20	June 11, 1985	0.3[b]
	Parr released Sept., 1985	April 10	April 22	April 25	-	15	Sept. 18-19,1985	0.7
	Parr released Nov., 1985	April 10	April 21	April 25	-	15	Nov. 19-20,1985	8.6
1985	Trucked smolts	May 4	May 13	May 20	3.7	16	April 11	23.4
	Pond smolts	April 30	May 6	May 20	6.0	19	April 12	20.4
	Parr released Sept., 1984	April 14	April 24	May 3	-	19	Sept. 11-12, 1984	8.8
	Parr released Nov., 1984	April 11	April 28	May 5	-	24	Nov. 6-7, 1984	3.3
1984	Trucked smolts	May 9	May 16	May 20	4.4	11	April 10	34.9
	Pond smolts	April 30	May 7	May 16	3.3	16	April 15	58.1
1983	Trucked smolts	May 3	May 7	May 15	6.9	12	April 20	20.6
	Pond smolts	May 2	May 3	May 6	7.5	4	April 20	38.5

[a]Bases on median release date of April 18 (two equal releases on April 9 and April 28).
[b]Represents smolts at Prosser. Including fish that migrated as pre-smolts the previous year, total "survival" was 3.2 percent.

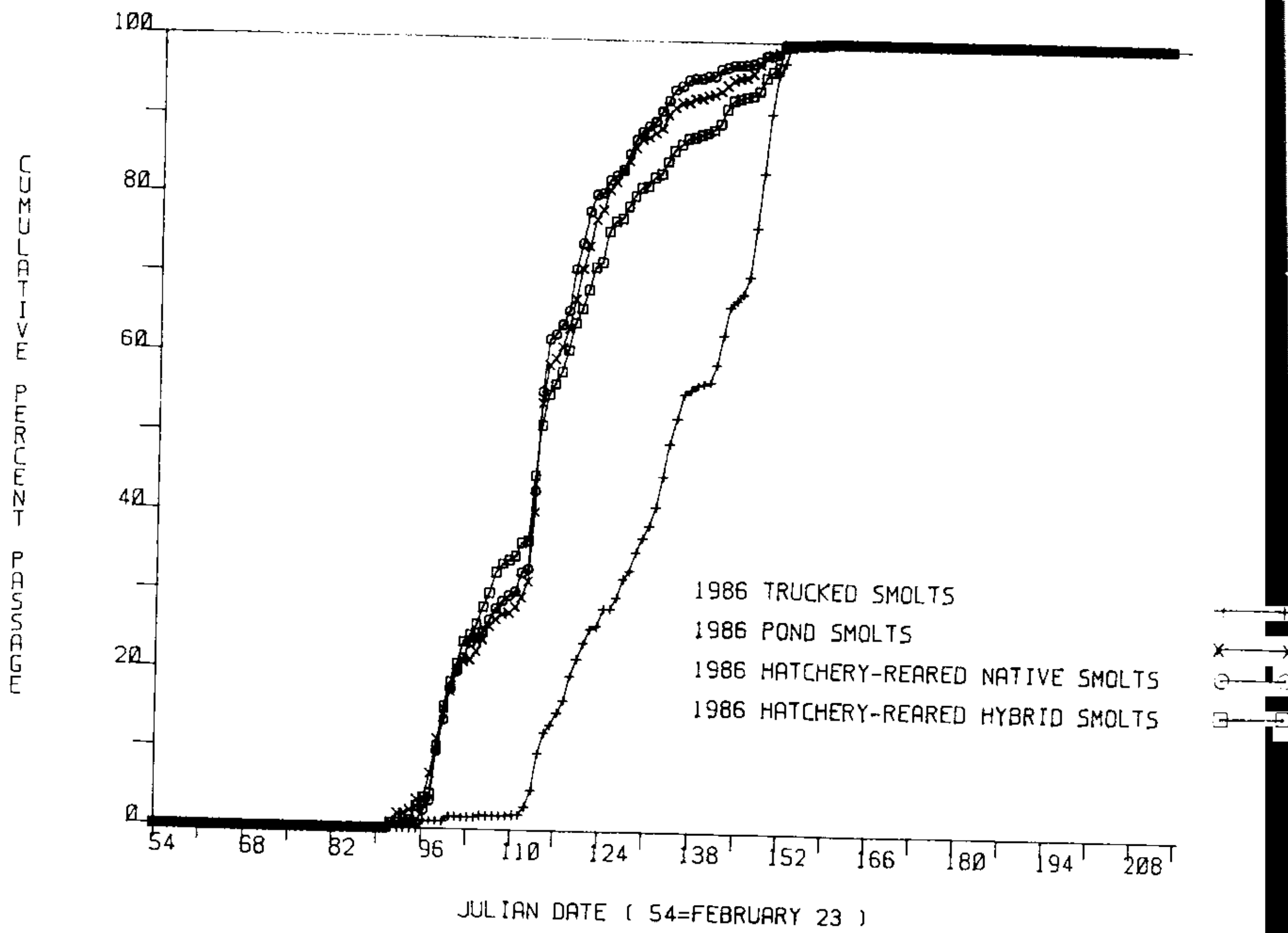


Figure 10. Cumulative percent passage past Prosser Dam of all 1986 experimental releases of hatchery-reared spring chinook smolts.

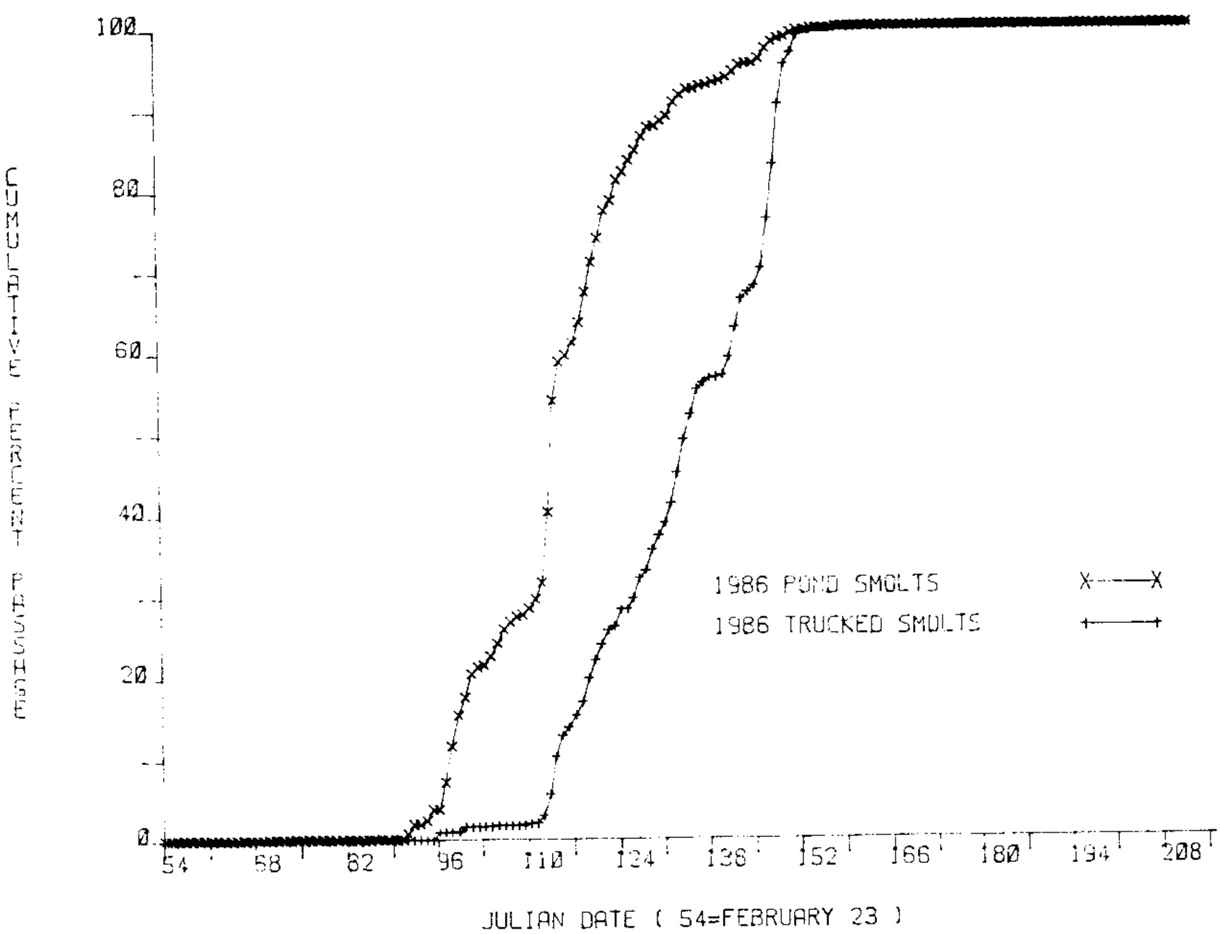


Figure 11. Cumulative percent passage of trucked (non-acclimated) and pond (acclimated) hatchery spring chinook smolts past Prosser Dam in 1986.

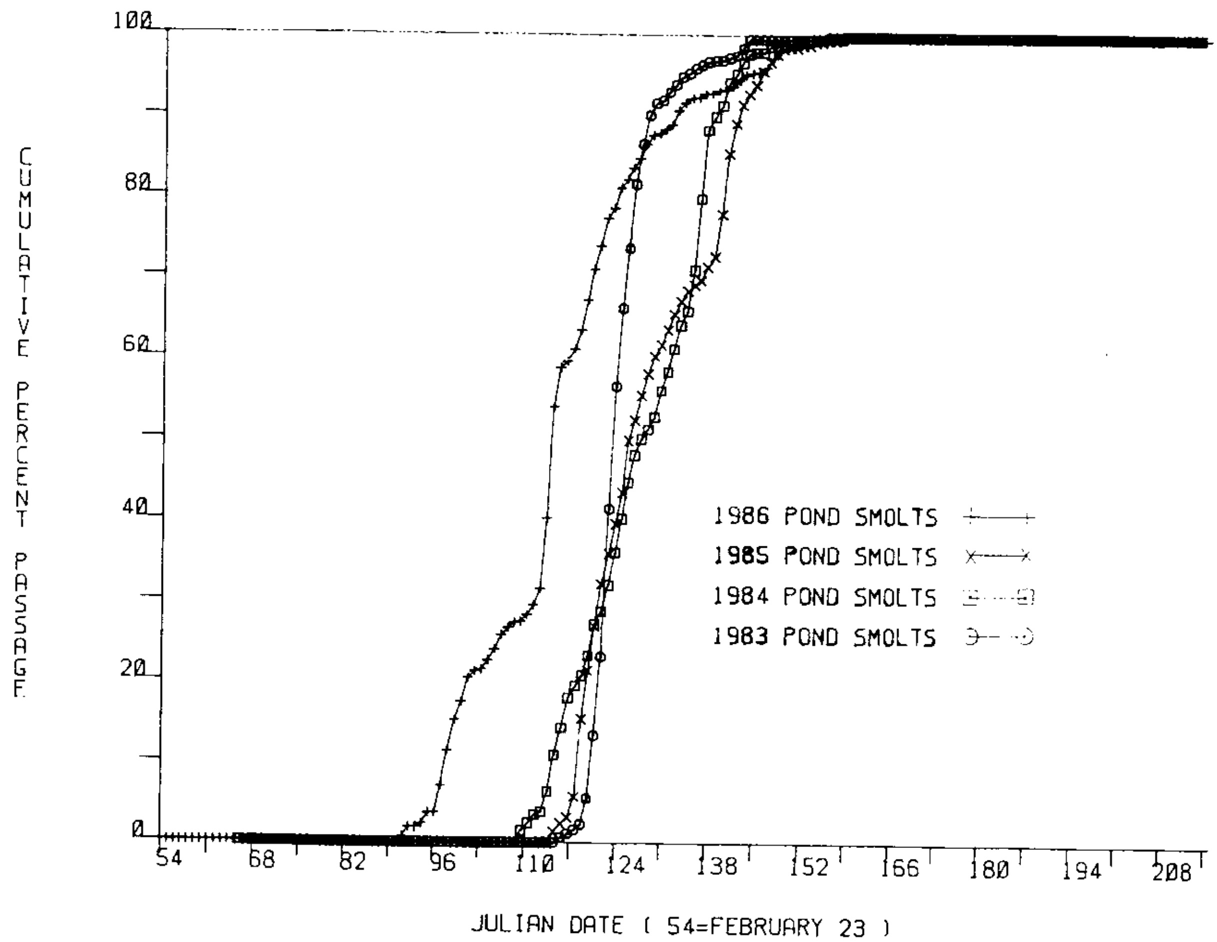


Figure 12. Cumulative percent passage of acclimated (pond) hatchery spring chinook smolts past Prosser Dam in 1983, 1984, 1985 and 1986.

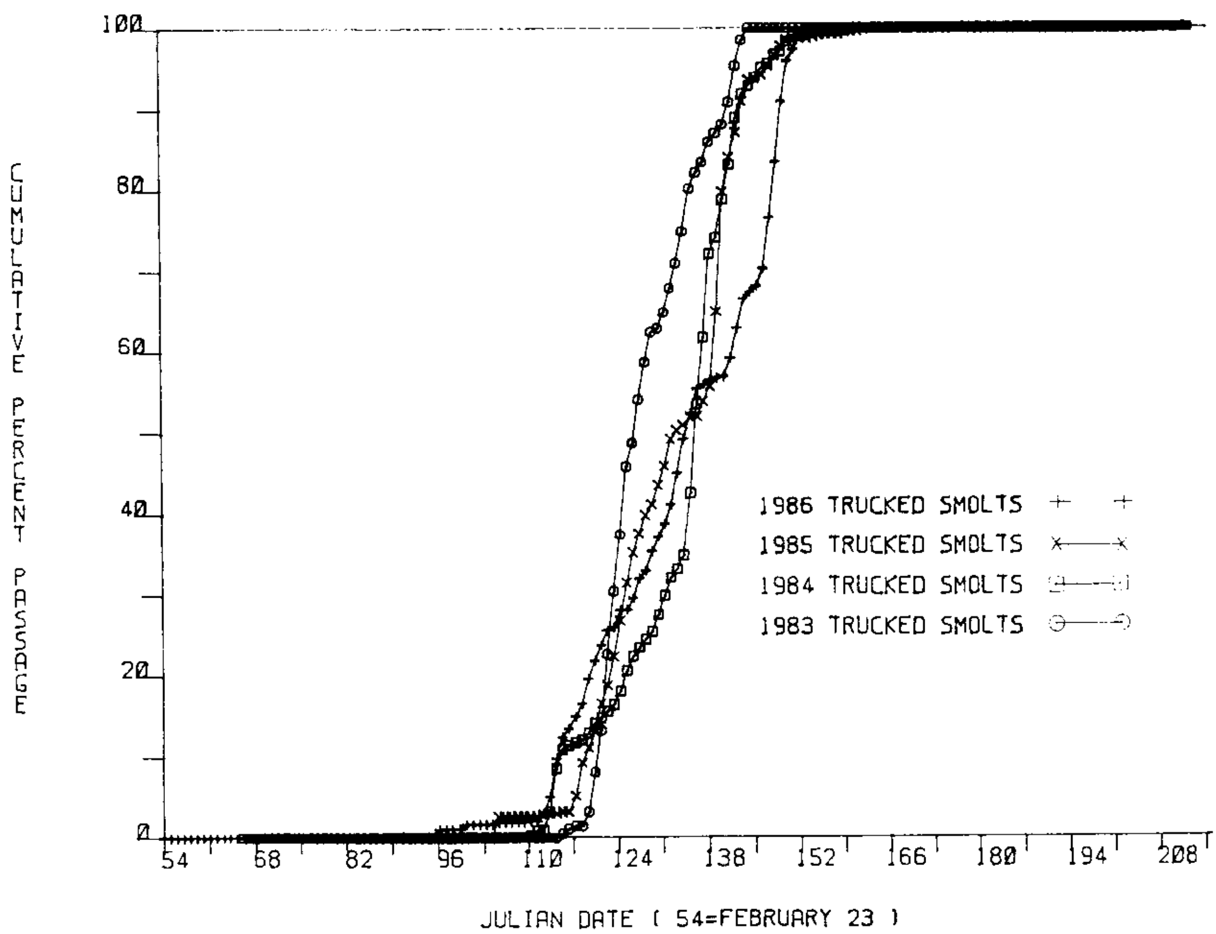


Figure 13. Cumulative percent passage past Prosser Dam of trucked (non-acclimated) hatchery spring chinook smolts in 1983, 1984, 1985 and 1986.

through third quartiles) to reach Prosser Dam. Related to 1985, when the same acclimation pond was used, the 1986 acclimated groups reach Prosser roughly "in register" with their release dates: the 1986 groups were released roughly two weeks earlier and, relative to 1985, all points of passage were also advanced about two weeks. The most salient difference between passage of the 1986 trucked smolts and those in previous years is the duration of passage. Elapsed time between passage of the first and third quartiles was from one and one-half to two times greater in 1986.

Differences in length and weight between 1986 test groups before release and as recaptured were negligible (see Table 23). The condition factor of all groups dropped noticeably after release. In May the condition factor of both hatchery release groups was substantially lower than it was in groups with a native Yakima genetic component.

Numerous factors may have contributed to the poor survival of the trucked group relative to the acclimated groups in 1986. First, the bulk of the trucked fish reached Prosser in May whereas the bulk of the acclimated groups arrived in the latter half of April. Mean water temperature at Prosser in May was about 5°C greater than the mean temperature in the latter half of April and losses to disease and predators may have been correspondingly higher. Second, river flows below Sunnyside Dam were much lower in May than in late April. The Yakima River below Sunnyside Dam had, by mid-May, shrunk in many places to narrow channels where piscivorous fish and smolts were concentrated. Many other places

Table 23. Mean length, weight and condition factor of spring chinook test releases monitored at Prosser Trap in 1986.

Group	At release			March			April			May			June			Survival to Prosser
	Fork length (mm)	Weight (gm)	Condition factor[a]	Fork length (mm)	Weight (gm)	Condition factor[a]	Fork length (mm)	Weight (gm)	Condition factor[a]	Fork length (mm)	Weight (gm)	Condition factor[a]	Fork length (mm)	Weight (gm)	Condition factor[a]	
Truckee[a]	124.6	22.8	11.4	-[d]	-[d]	-[d]	146.3	43.8	10.6	146.0	32.8	9.8	151.3	n.d.	n.d.	8.0
Pond[b]	124.4	22.0	11.2	-[d]	-[d]	-[d]	142.5	34.0	10.4	142.1	23.7	8.4	148	35.3	10.6	16.7
Hybrid[b]	129.9	26.4	11.6	-[d]	-[d]	-[d]	143.4	36.7	10.3	144.6	34.8	10.2	148	n.d.	n.d.	17.6
Native[b]	128.7	26.5	11.5	-[d]	-[d]	-[d]	152.7	41.5	10.7	146.4	33.2	10.7	150.0[e]	n.d.	n.d.	18.9
June 1985 fry	83	7.3	12.8[c]	123.7	19.2	10.1	147.8	42.8	9.7	136.8	n.d.	n.d.	n.d.	n.d.	n.d.	0.3[f]
September 1985 parr	111	19.8	14.5[c]	150.0	35.2	10.4	136.4	20.8	9.7	141.1	25.4	9.3[e]	n.d.	n.d.	n.d.	0.7
November 1985 parr	122	21.2	11.5[c]	147.8	34.1	10.4	137.6	30.1	10.1	139.4	25.7	10.0	n.d.	n.d.	n.d.	8.6

Note: No length or weight data was taken prior to March, and no recaptures of test fish occurred after June.

n.d.: Denotes no data.

[a]Expressed as $(W/L^3) \times 1{,}000{,}000$ where W=weight in grams and L=fork length in milimeters.
[b]Data taken March 6 and 7, 1986. Release occurred March 28, 1986.
[c]Computed fom mean weight and mean length, not the mean of individual condition factor values.
[d]No recaptures occurred in March.
[e]N=1.
[f]Represents spring smolts only.

consisted of broad, shallow riffles that afforded excellent fishing sites for gulls and herons. Thus, due to a decline in river flow both the duration and degree of vulnerability to fish and avian predators were greater for trucked smolts than for acclimated smolts.

6.1.3.7.2 Survival to Smolt of Fall-Released Chinook Parr

The total number of LNFH spring chinook parr scatter-planted at the usual sites on the upper Yakima in September and November of 1985 was 101,724 and 95,431 respectively. The number of branded fish in these releases were 10,489 and 10,526. It was estimated that 76 branded fish (0.7 percent) from the September release and 907 (8.6 percent) from the November release migrated to Prosser in 1986. These survival figures must be qualified somewhat by the fact a number of branded fish from both releases were caught in the fyke net the few days it was fished in January and February. The possibility exists that a substantial outmigration of these fish occurred before the net was placed in the canal.

There was virtually no difference in the timing of outmigration for the September and November releases in 1986 (Figure 14, Table 22). Both groups, however, migrated to Prosser about a week ahead of comparable groups in 1985 (Figures 15 and 16).

Mean length, weight and condition factor (Table 24) for September and November fish were also quite similar. At release, however, the September group had a substantially higher condition

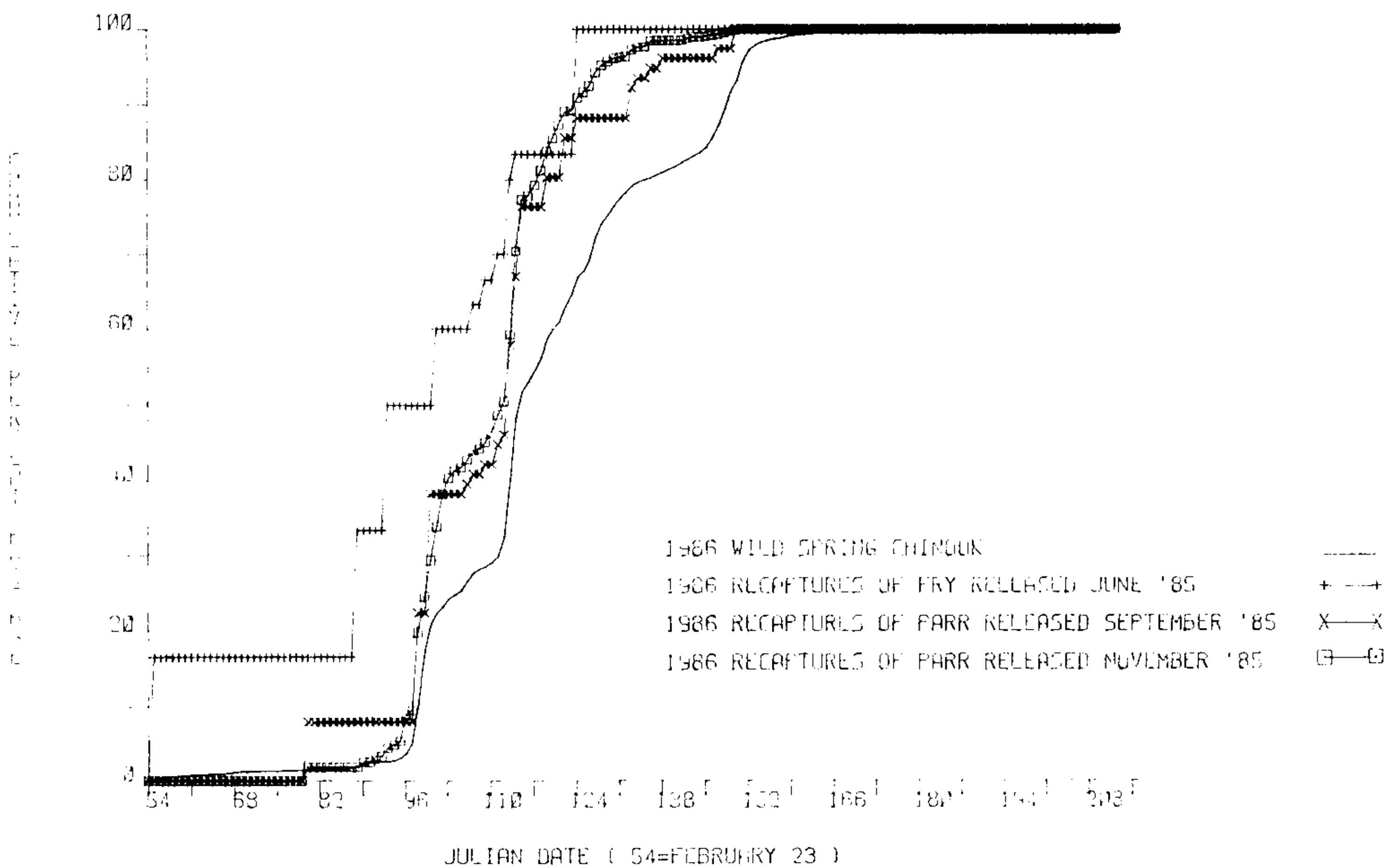


Figure 14. Cumulative percent passage past Prosser Dam in the spring of 1986 of wild and experimental hatchery spring chinook smolts. The hatchery fish were released as pre-smolts in June, September and November of 1985.

Table 27. Revised run timing and survival rates for wild and hatchery steelhead, 1983-1986.

Year	Group	Hatchery steelhead release date	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage	Time elapsed between first and third quartrile (days)	Median migration rate hatchery steelhead (mi/day)	Hatchery steelhead survival (percent)
	Wild		March 30	April 20	May 11	42		
1986	hatchery	March 31	May 11	May 22	May 29	18	1.4	22.1
	Wild		April 22	May 5	May 18	26		
1985	hatchery	April 8	April 22	May 1	May 18	26	3.2	35.8
	Wild		April 21	May 5	May 16	25		
1984	hatchery	April 17	April 24	May 1	May 12	19	5.2	24.7
	Wild		April 24	May 3	May 17	23		
1983	hatchery	April 8	May 3	May 9	May 18	15	2.3	17.7

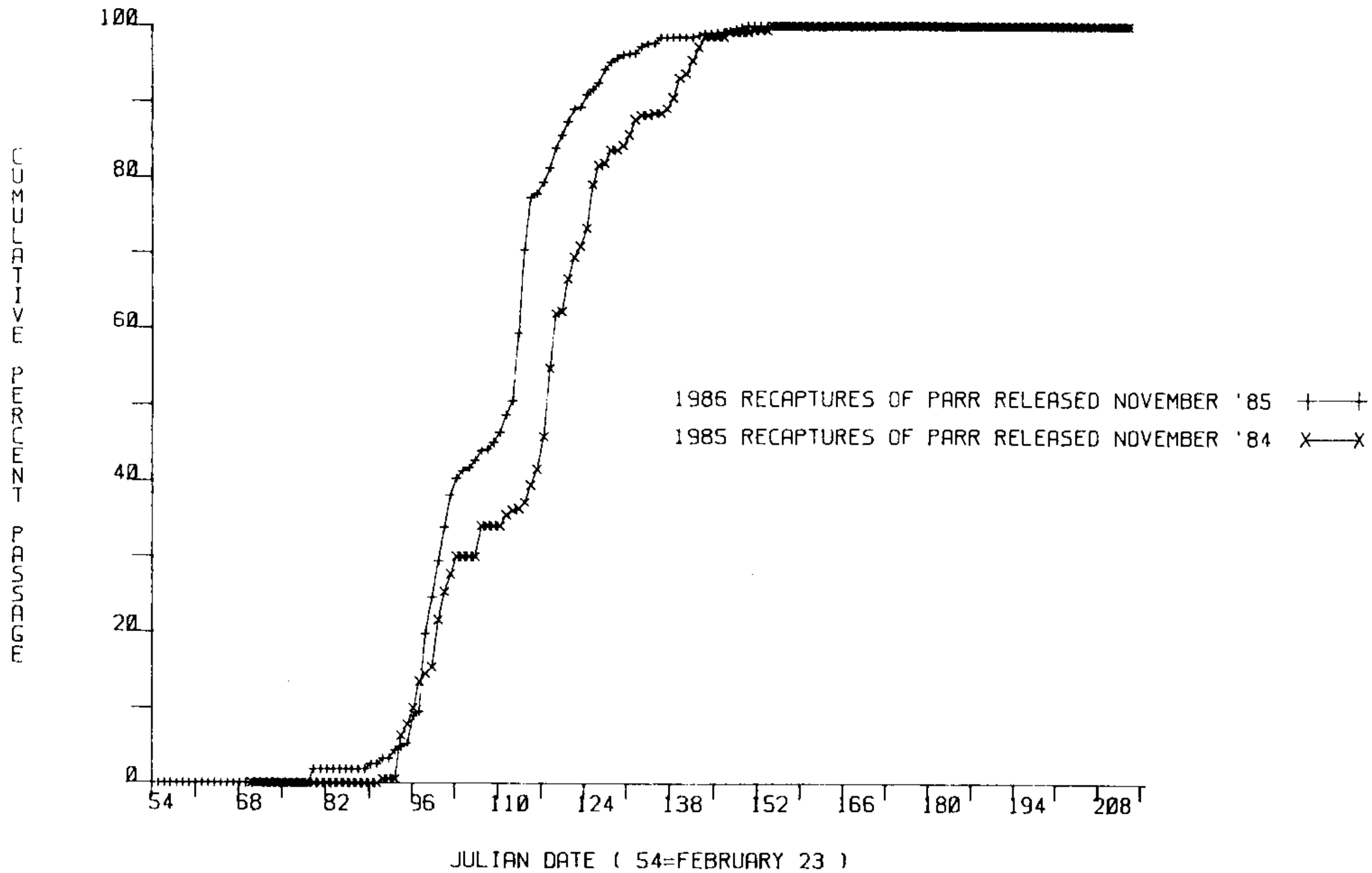


Figure 16. Cumulative percent passage past Prosser Dam of hatchery spring chinook smolts released as pre-smolts in November of 1984 and 1985. Recaptures from the 1984 release occurred in 1985, and recaptures from the 1985 release occurred in 1986.

Table 24. Mean length, weight and condition factor of hatchery spring chinook released September and November 1984 and 1985. Monthly means describe recaptures the following year - 1986 for groups released in 1985, and 1985 for groups released in 1984.

Group	At release			March			April			May			June			Survival to Prosser (percent)
	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	
September 1985 parr	111	19.8	14.5[b]	150	35.2	10.4	136.4	20.8	9.7	141.1	25.4[c]	9.3[c]	n.d.	n.d.	n.d.	0.7
November 1985 parr	122	21.2	11.7[b]	147.8	34.1	10.4	137.6	30.1	10.1	139.4	24.7	10.0	n.d.	n.d.	n.d.	8.6
September 1984 parr	115	18.1	11.9[b]	182[c]	69.0	11.4[c]	147.0	33.3	10.4	144.7	30.4	9.8	151	39.2	11.1	8.8
November 1984 parr	117	21.0	13.1[b]	n.d.	n.d.	n.d.	153.4	39.4	10.2	148.2	34.2	10.0	151[c]	34.8[c]	10.1[c]	3.3

[a]Expressed as $(W/L^3) \times 1{,}000{,}000$ where W = weight in grams and L = fork length in milimeters.
[b]Based on mean length and mean weight.
[c]N = 1.

factor than the November group.

The relative survival of September and November-released parr in 1985 was the reverse of 1986: in 1985 the survival of September fish was 2.5 times the survival of November fish (see Table 22). This difference might be attributable to differences in over-winter survival rates and/or fall-winter migratory behavior. There is no evidence of a possible difference in migratory behavior and virtually nothing on differential survival. One fact, however, may be significant: of parr released in the fall of 1984 and 1985 the group with the lower survival rate in 1985 and 1986 had the higher condition factor at release. Unusually high condition factors might reflect poor physical conditioning or perhaps an undiagnosed edematous disease such as BKD.

6.1.3.7.3 Survival to Smolt of June-Released Chinook Fry

In 1986, for the first time, branded smolts that had been planted as fry the previous summer were observed at Prosser the following spring. The estimated 1986 outmigration was, however, only 30 fish. A total of 101,191 fry, 9,102 of which were branded, were released June 11, 1985. As an estimated 264 branded fish migrated to Prosser in June and July of 1985, the total outmigration over both years was 294, or 3.2 percent.

The timing of the few fish to reach Prosser as smolts was considerably earlier than either wild spring chinook or the fall release groups (Figure 14, Table 22). The mean lengths and weight of these smolts was somewhat greater than wild smolts but was similar to other hatchery release (see Table 23).

6.1.3.7.4 Hatchery Fall Chinook Releases

On May 20, 1986, 97,460 hatchery fall chinook were released at Sunnyside Dam. All fish were ad-clipped and were thus easily distinguished from wild fall chinook. Total estimated outmigration was 32,104, or 32.9 percent,

The timing of the outmigration in 1986 was similar to that of the 1985 and 1984 releases (which occurred in the same general area) when allowance is made for different release dates (see Table 25 and Figure 17). Mean length, weight, and condition factor were also comparable among releases (see Table 26).

An explanation for the increased survival of the 1986 release is not obvious. The 1986 release was made roughly three weeks earlier than in 1984 and 1985 because the mean water temperature at Prosser during outmigration of the 1985 release was about 21 ^{o}C. It was hoped that an earlier release would preclude temperature problems and result in a survival rate higher than the disappointing 16.8 percent observed in 1985. Although the survival rate in

Table 25. Revised run timing and survival rates of hatchery fall chinook releases, 1984-1986.

Year	Release date	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage	Time elapsed between 1st & 3rd quartiles (days)	Survival (percent)
1986	May 20	June 8	June 12	June 16	8	32.9
1985	June 13	June 28	July 12	July 5	7	16.8
1984	June 15	July 4	July 6	July 10	6	25.8

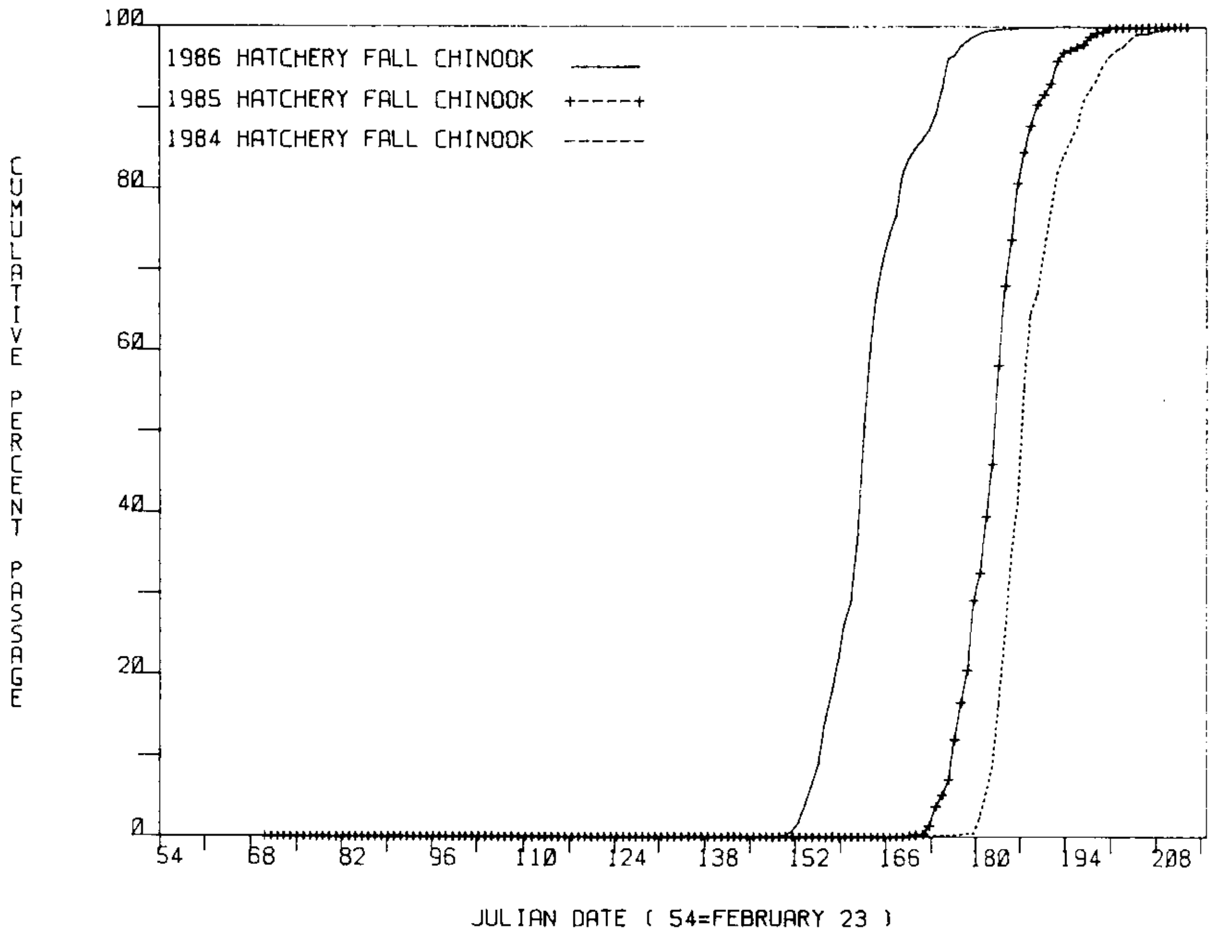


Figure 17. Cumulative percent passage past Prosser Dam of hatchery fall chinook smolts in 1984, 1985 and 1986.

Table 26. Mean monthly length, weight and condition factor of hatchery fall chinook released at Sunnyside Dam 1984-1986.

Year	May Fork length (mm)	May Weight (gms)	May Condition factor[a]	June Fork length (mm)	June Weight (gms)	June Condition factor[a]	July Fork length (mm)	July Weight (gms)	July Condition factor
1986	88.4	7.5	11.1	89.4	8.7	12.1	107.5	-c	-c
1985	-b	-b	-b	90.2	8.6	10.6	104.2	12.7	10.7
1984	-b	-b	-b	91.4	-c	-c	104.2	-c	-c

[a]Expressed $(W/L^3) \times 1{,}000{,}000$ where W = weight in grams and L = length in millimeters.
[b]Not released until June.
[c]Balance malfunction precluded gathering weight data.

1986 was twice as great as in 1985, differential water temperature cannot have been the cause: mean water temperature at Prosser during the 1986 hatchery fall chinook outmigration was 20.5 °C. Moreover mean Prosser water temperature during the 1984 outmigration, for which survival was also substantially lower than in 1986, was a comparatively cool 17 °C. Differential river flows clearly played no role, as discharge in 1986 was the lowest since the study began. A possible explanation would invoke depensatory mortality. If the number of smolts lost to predators per unit time is the same in June and July, more hatchery fall chinook would be lost in a July outmigration because they would constitute a greater proportion of available prey.

6.1.7.5 Hatchery Steelhead

The Yakima chapter of the Northwest Steelheaders Club of

America released 89,200 ad-clipped hatchery steelhead from Nelson Springs Hatchery (Naches River, RM 3.3) on March 31, 1986. Release was volitional until April 13 when remaining fish were crowded from the raceway. It was estimated that 19,689, or 22.1 percent, of these fish subsequently migrated to Prosser Dam (see Tables 20 and 27).

In spite of the earliest release date in four years, the 1986 hatchery steelhead run was the latest and slowest recorded to date (Figure 18, Table 27). By May 1, a full month after release, only eight percent of the run had reached Prosser. When they finally started arriving in some numbers, the middle 50 percent of the hatchery run reached Prosser in a period comparable to previous years, but the run as a whole was two to three weeks later than any run, wild or hatchery, since 1983.

Mean monthly length, weight and condition factor in 1986 was comparable to previous years with two exceptions (see Table 20). The 1983 release consisted of much smaller, more robust fish than have been released in the past three years and monthly means simply reflect release size. More significantly, the mean condition factor of 1986 fish in May, when the bulk of run reached Prosser, was the lowest yet observed. Survival thus appears to be more a function of smolt quality than any other factor. Since 1983, increased survival of hatchery steelhead has been associated with size and condition factor, whereas release date and river flow have had little apparent effect (see Table 28). Survival was greatest in 1985; fish were large, their condition factor approached that of wild fish and there were relatively few observations of fish with stubbed fins or serious descaling.

Table 27. Revised run timing and survival rates for wild and hatchery steelhead, 1983-1986.

Year	Group	Hatchery steelhead release date	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage	Time elapsed between first and third quartrile (days)	Median migration rate hatchery steelhead (mi/day)	Hatchery steelhead survival (percent)
	Wild		March 30	April 20	May 11	42		
1986	hatchery	March 31	May 11	May 22	May 29	18	1.4	22.1
	Wild		April 22	May 5	May 18	26		
1985	hatchery	April 8	April 22	May 1	May 18	26	3.2	35.8
	Wild		April 21	May 5	May 16	25		
1984	hatchery	April 17	April 24	May 1	May 12	19	5.2	24.7
	Wild		April 24	May 3	May 17	23		
1983	hatchery	April 8	May 3	May 9	May 18	15	2.3	17.7

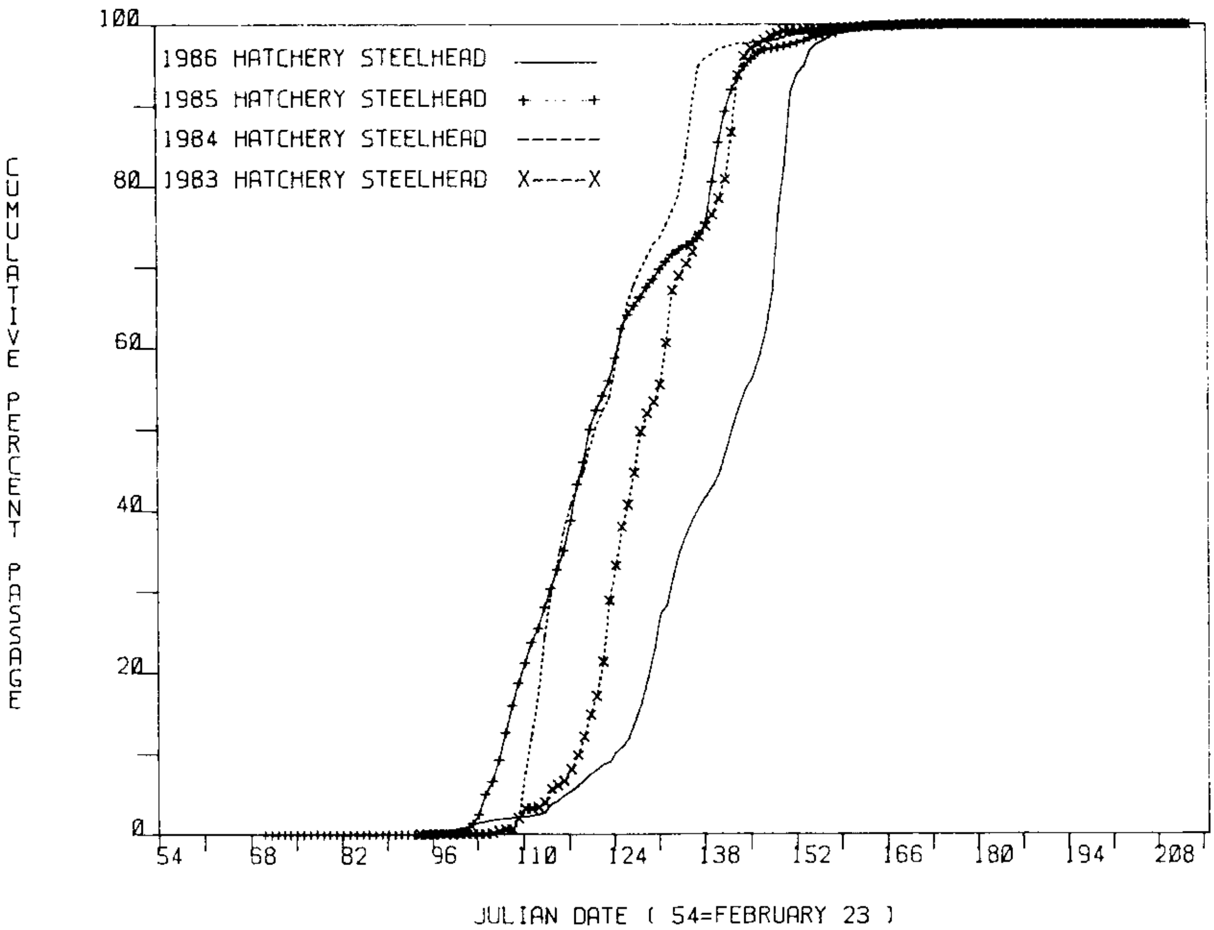


Figure 18. Cumulative percent passage past Prosser Dam of hatchery steelhead smolts in 1983, 1984, 1985 and 1986.

Table 28. Summary of factors pertinent to survival of hatchery steelhead released in Yakima River, 1983-86.

Year	Release date	Mean discharge at Prosser from date of release to date of 75 percent passage (cfs)	Mean fork length, all fish (mm)	Mean condition factor, all fish[a]	Migration rate (mi/day)	Survival (percent)
1986	March 31	2950	217	8.2	1.4	22.1
1985	April 8	3092	214	8.9	3.2	35.8
1984	April 17	3040	201	8.4	5.2	24.7
1983	April 8	5946	140	10.7	2.3	17.7

[a]Condition factor calculated as $(W/L^3) \times 1,000,000$ where L = fork length in millimeters, W = Weight in grams.

6.1.3.7.6 Pond-Reared Coho

Approximately 100,000 hatchery coho were reared in Nile pond (RM 29.4, Naches River) from June, 1985 until March 31, 1986, when they were allowed volitional release into the Naches River. As indicated by an automatic fish counter, 84,879 left the pond between April 1 and May 23. A total of 43,733 fish, or 51.1 percent, survived to Prosser Dam.

The size and degree of smoltification of these coho spanned a very wide range. It would appear that fish began actively migrating as they became physiologically ready, with the small number of large fish leaving immediately and the majority of smaller fish lingering until smoltification was complete. Such a scenario is supported by the timing of the run and the progressive decrease in the size of fish in it (Tables 29 and 30 and Figure 19).

Table 29. Run timing of hatchery coho reared in Nile pond released March 31, 1986.

Release date	Date of 25 percent passage	Date of 50 percent passage	Date of 75 percent passage	Elapsed time between passage of 1st & 3rd quartiles (days)	Migration rate (mi/day)
March 31	May 11	May 27	May 29	18	1.7

Table 30. Mean length, weight and condition factor of Nile pond hatchery coho by month of capture at Prosser smolt trap, 1986.

April			May			June			July		
Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]	Fork length (mm)	Weight (gms)	Condition factor[a]
175.4	52.9	9.5	160.5	39.6	9.2	136.6	26.7	9.7	132.8	-[b]	-[b]

[a]Expressed as $(W/L^3) \times 1{,}000{,}000$ where W = weight in grams and L = fork length in milimeters.

[b]Balance malfunction precluded weight data.

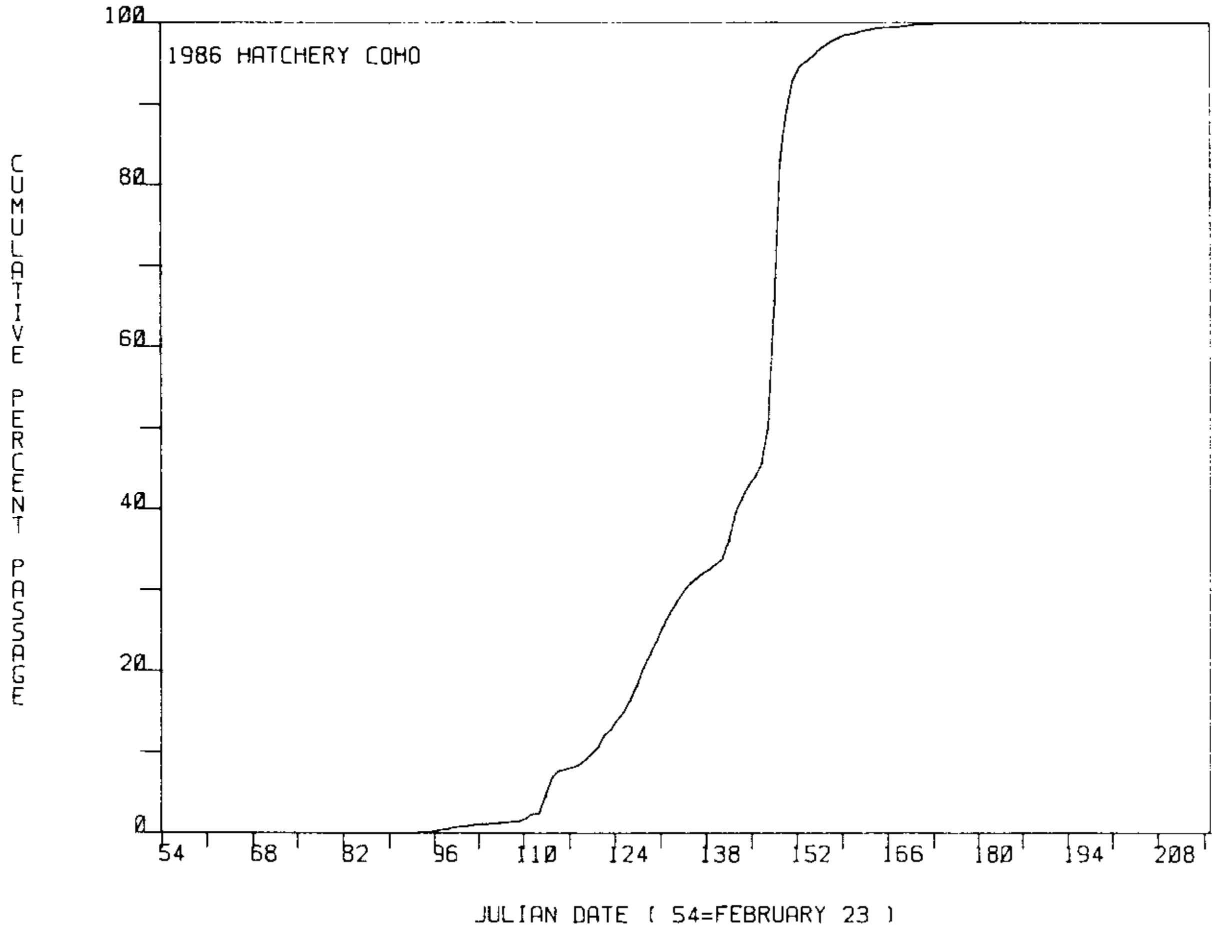


Figure 19. Cumulative percent passage past Prosser Dam of hatchery coho smolts released from Nile Pond in 1986.

6.1.3.8 Relationship Between Spring Discharge and Smolt Survival

It has been proposed that spring flows are responsible for much of the yearly variation in survival of outmigrating smolts (Fast et. al., 1985). The mechanism put forth may be summarized as follows. Some of the movement of outmigrating smolts is tail-first and passive, with active swimming mainly occurring in the slowest reaches. Outmigration should therefore be delayed in years of low flow as mean velocity is known to decrease quite rapidly with falling discharge. Moreover, outmigration would entail more active swimming in years of low discharge, and smaller, slower-swimming smolts would be delayed even more than their larger cohorts. Assuming pre-smolt mortality constant and outmigrant mortality proportional to migration time, egg-to-smolt survival should fall in low flow years. In addition, if pre-migration size distributions are equivalent from year to year, losses of smaller, more vulnerable, and slower moving smolts should increase the mean size of surviving migrants when flows are low during the smolt run.

Many of the relationships outlined above have been confirmed by similar investigations in other places. Dawley et. al. (1986) summarized 17 years of research on smolt outmigration to the Columbia estuary and reported that:

1) The survival of yearling chinook from sites on the Snake River to the Dalles Dam is positively correlated with spring discharge.
2) The migration rate of yearling chinook released at McNary Dam was positively correlated with discharge, and the migration

rate of sub-yearling chinook released below John Day Dam was positively correlated with release size, discharge, degree of smoltification (using ATPase activity as an index) and distance from release point to the estuary.

3) Survival of groups of spring chinook smolts from Willamette River hatcheries matched by stock, rearing history and release time was significantly greater for groups with a larger release size. And finally,

4) Releases of chinook, coho and steelhead sampled at several places from release point to estuary revealed a progressive loss of small individuals.

The importance of discharge to spring chinook outmigration in the Yakima River within a single season was once again evident in 1986. Figures 20 and 21 demonstrate that both spring chinook and steelhead synchronized their movements with periods of rising discharge. Behavior in the years 1983-1985 was similar (Fast et. al., 1985).

The effects of mean spring discharge across seasons in the Yakima system are obscured in some cases by lack of information and in others by the absence of meaningful controls. From year to year wild spring chinook outmigrations are matched by stock and by rearing history. The Yakima Canyon, the principal rearing area in the system, has been subject to little environmental disturbance; is not subject to extreme fluctuations in discharge and has numerous deep holes to provide overwintering habitat. However, because it has

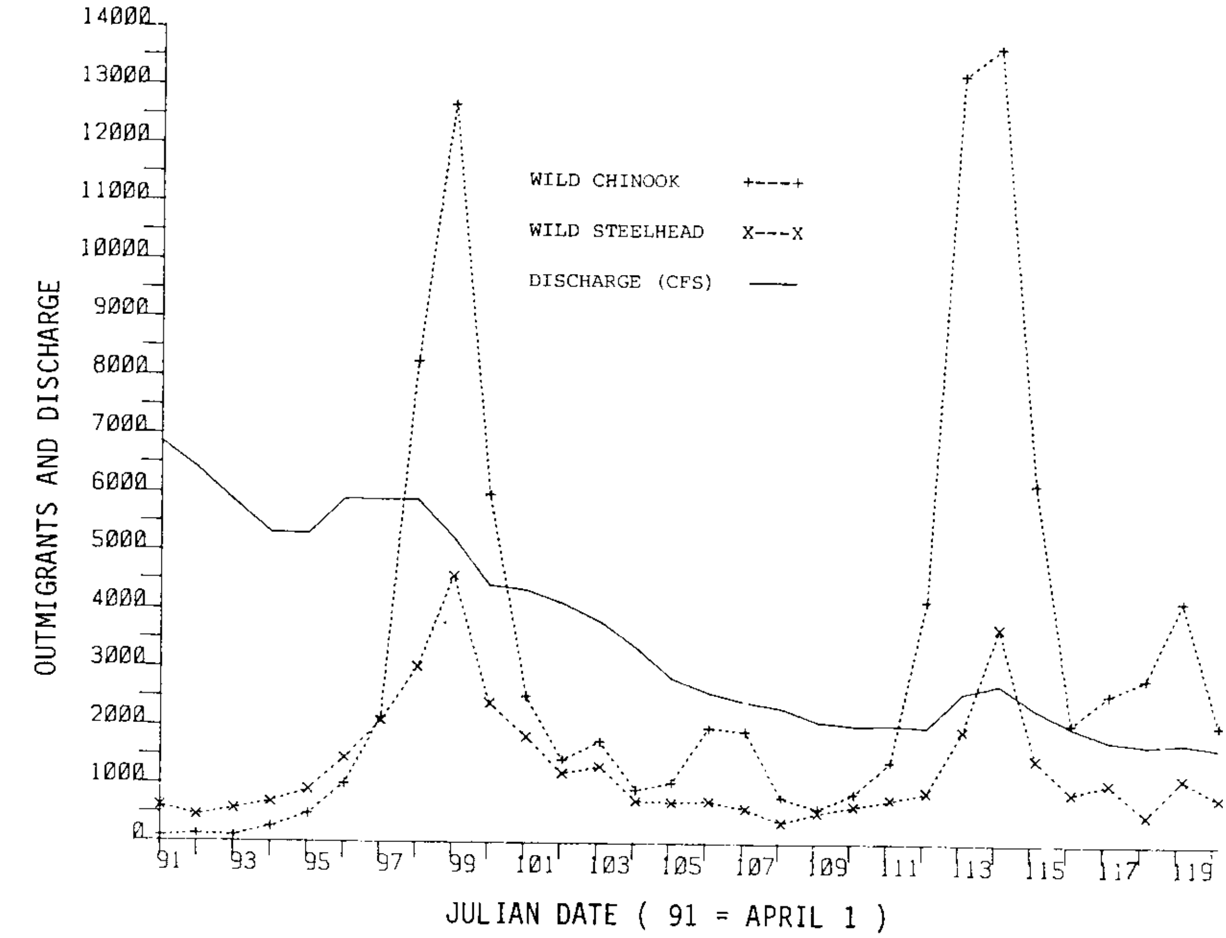


Figure 20. Mean daily discharge at Prosser Dam and estimated outmigration of wild spring chinook and steelhead smolts in April, 1986.

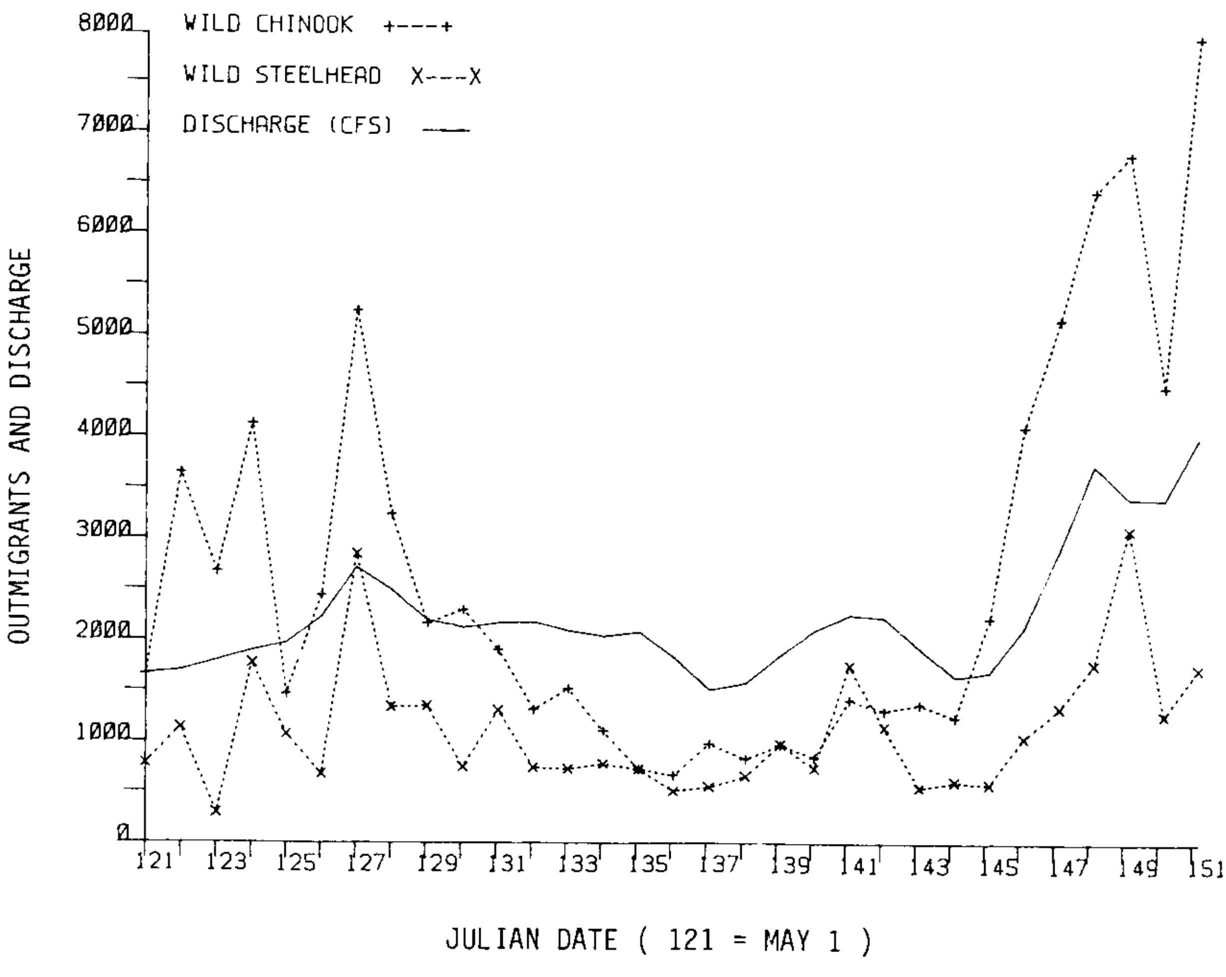


Figure 21. Mean daily discharge at Prosser Dam and estimated outmigration of wild spring chinook and steelhead smolts in May, 1986.

not been possible to describe the "start" of a wild smolt run---the median place and time and the number of individuals involved---it has not been possible to estimate either the speed or the "in-transit survival rate" of an individual migration. For releases of hatchery fish, migration rate and survival are easily estimated. The effect of any single independent variable, such as variations in discharge or migration rate is, however, confounded with differences in stock, rearing history, and manner, time and place of release.

Even with these limitations, it is still possible to elucidate some aspects of the relationship between discharge and smolt outmigration in the Yakima system. Data collected since 1983 support the following relationships.

1. Increased spring discharge promotes survival of wild spring chinook outmigrants although uncontrolled variables obscure the impact on hatchery releases.
2. Gross increases in discharge are associated with accellerated outmigration.
3. There is little evidence to indicate larger smolts migrate faster, but there is some indication that faster outmigrants suffer fewer mortalities. Finally,
4. There is some evidence that larger smolts suffer fewer mortalities during migration.

Effect of spring discharge on smolt survival. If survival from egg to pre-smolt has been constant for wild spring chinook from 1983-1986, and if survival of migrating smolts is a function of spring discharge, then there should be a relationship between egg-to-smolt survival and discharge for these years. As Figure 22 indicates, such a relationship does exist. The correlation between egg-to-smolt survival and mean daily discharge (cfs) at Prosser in April and May is +0.991, and the correlation between survival and mean discharge in April alone is +0.972. Both regressions of discharge on survival are significant, but both depend heavily on one year (1983) of high discharge.

Effect of spring discharge on migration rate. As Figure 23 and Table 31 demonstrate, gross changes in spring discharge are associated with changes in run-timing of spring chinook smolts. Spring discharge in 1983 was roughly twice that of 1984, 1985 and 1986, and the passage of wild spring chinook in 1983 was clearly earlier and more abrupt than in later years. The same relationship is evident in a comparison of the migration rates of trucked smolts in 1983 with rates for 1984-1986, and in a comparison of the migration rate of pond smolts in 1983 and 1984 and in 1985 and 1986. (Nile pond was used for acclimation in 1983 and 1984, and Mary's pond in 1985 and 1986. Migration rate from the same pond was greater when discharge was greater).

Effect of migration rate on survival. Evidence bearing on the relationship between migration rate and survival is found in the results of marked hatchery coho and wild chinook released at Wapatox trap in 1986 (The results of truck and pond releases since 1983 and of marked wild chinook released at Wapatox in 1985 (Fast et. al., 1985) do not clarify the

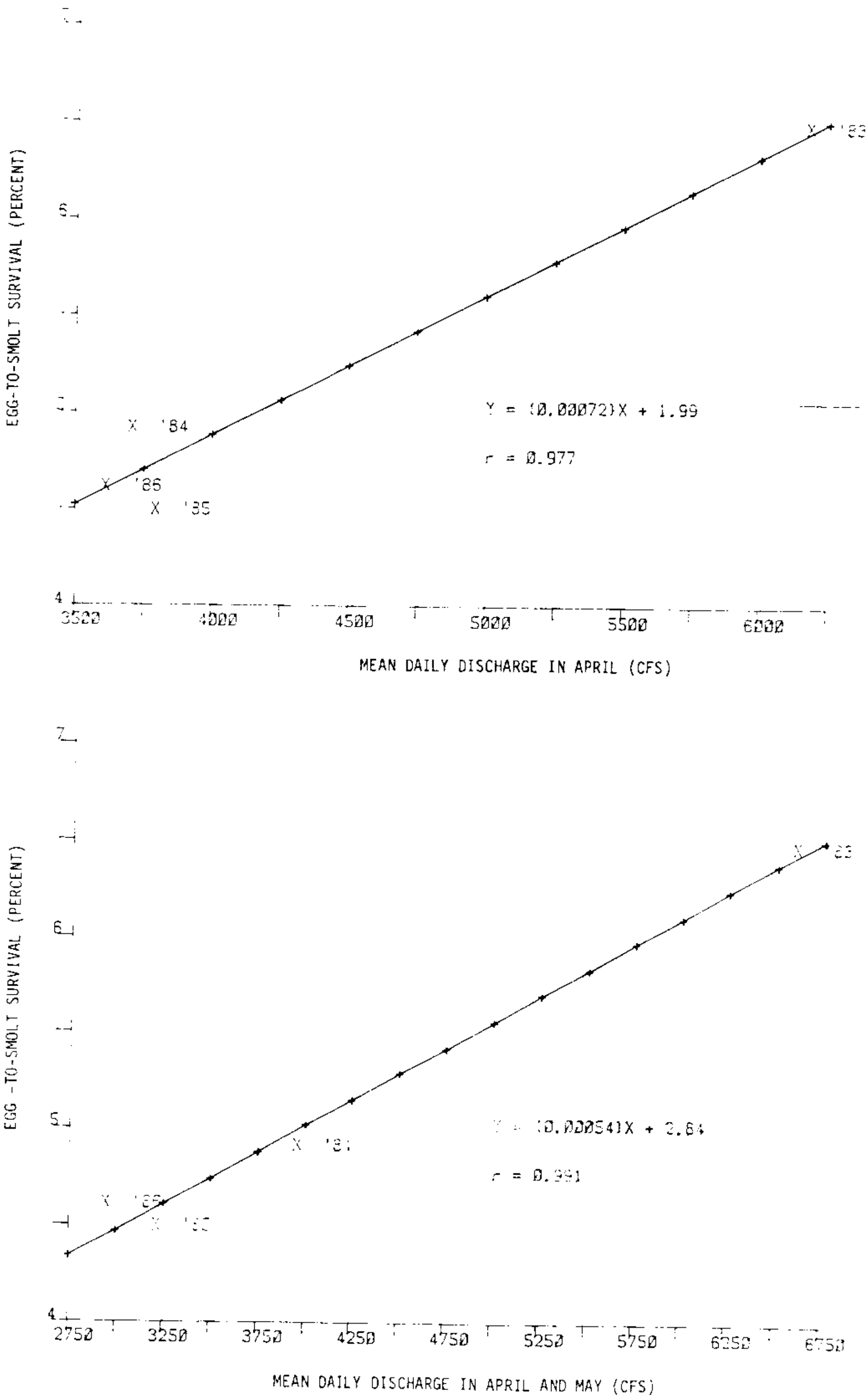


Figure. 22. Regressions of mean daily discharge in April, and in April and May combined on wild spring chinook egg-to-smolt survival in the years 1983-1986.

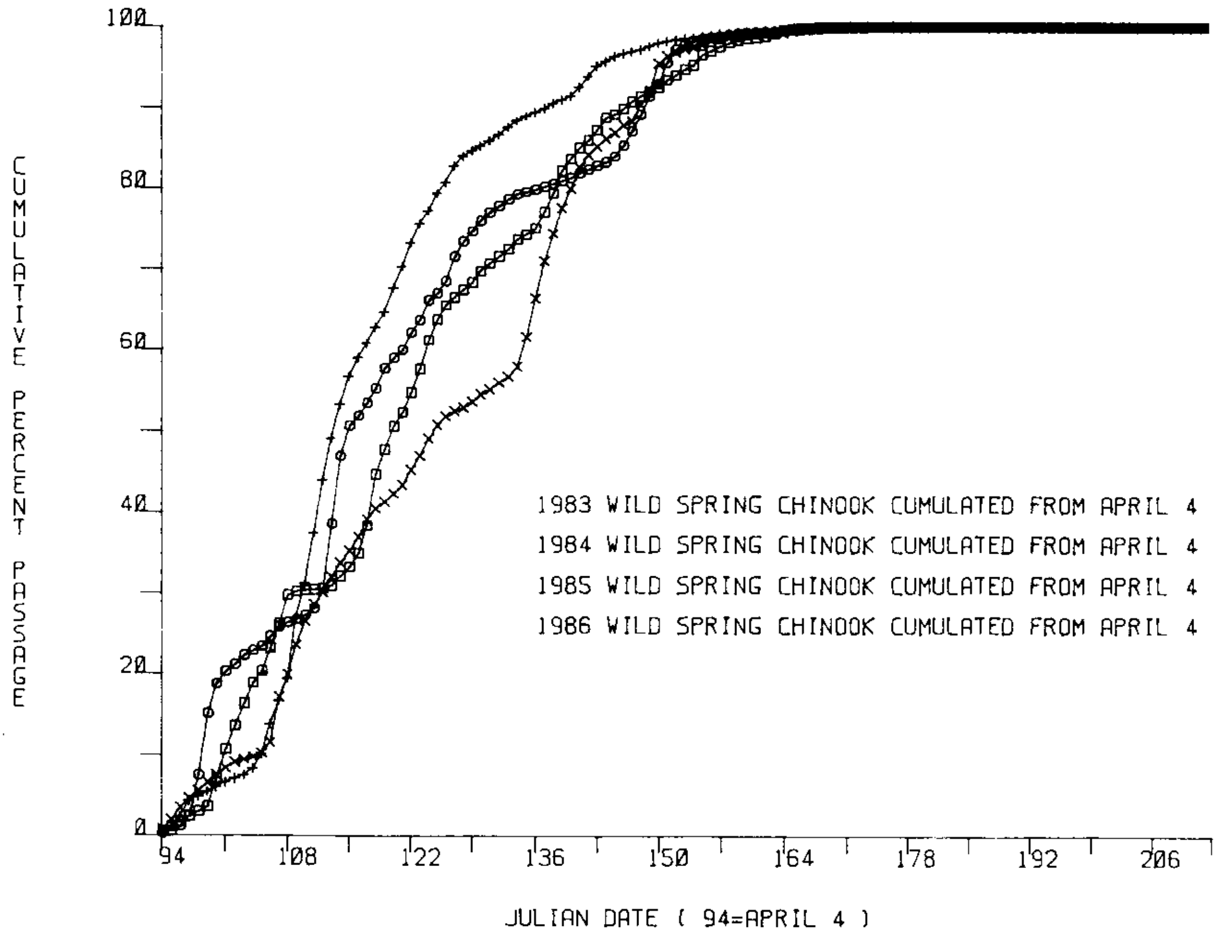


Figure 23. Cumulative percent passage past Prosser Dam of wild spring chinook smolts in the years 1983-1986. Data has been corrected for starting date by cumulating estimates from April 4, the latest date the smolt trap was opened.

Table 31. Mean spring discharge and revised estimates of run timing and survival for wild spring chinook smolts and selected hatchery spring chinook smolt releases, 1983-1986.

Year	Group	Mean discharge in April and May (cfs): Yakima Canyon	Mean discharge in April and May (cfs): Sunnyside Dam	Mean discharge in April and May (cfs): Prosser Dam	Date of 25 percent passage at Prosser	Date of 50 percent passage at Prosser	Date of 75 percent passage at Prosser	Elapsed time between first & third quartiles (days)	Median migration rate (mi/day)	Survival rate egg-to-smolt or release point to Prosser (percent)
1986	Wild spring chinook[a]	1868	1414	2922	April 17	April 25	May 10	23	—	4.6
	Ford hatchery chinook	1858	1414	2922	April 16	April 24	May 1	15	5.4	16.7
	Trucked hatchery chinook	1858	1414	2922	May 2	May 14	May 27	25	4.5	8.0
	Acclimated hatchery-reared native smolts	1868	1414	2922	April 14	April 24	May 4	20	5.4	18.9
	Acclimated hatchery-reared hybrid smolts	1858	1414	2922	April 15	April 24	May 1	16	5.4	17.6
	Hatchery chinook parr released Sept., 1985	1858	1414	2922	April 10	April 22	April 25	15	—	0.7
	Hatchery chinook parr released Nov., 1985	1858	1414	2922	April 10	April 21	April 25	15	—	8.6
1985	Wild spring chinook[a]	2914	2034	3189	April 17	April 30	May 17	30	—	4.5
	Ford hatchery chinook	2914	2034	3189	April 30	May 6	May 19	19	6.0	20.4
	Trucked hatchery chinook	2914	2034	3189	May 4	May 13	May 20	16	3.7	23.4
	Hatchery chinook parr released Sept., 1984	2914	2034	3189	April 14	April 24	May 3	19	—	8.8
	Hatchery chinook parr released Nov., 1984	2914	2034	3189	April 11	April 28	May 5	24	—	3.3
1984	Wild spring chinook[a]	3236	2554	3931	April 20	May 5	May 17	27	—	4.9
	Ford hatchery chinook	3236	2554	3931	April 30	May 7	May 16	14	4.4	58.1
	Trucked hatchery chinook	3236	2554	3931	May 9	May 16	May 20	11	3.3	34.9
1983	Wild spring chinook[a]	4046	4767	6576	May 3	May 7	May 3	14	—	6.4
	Ford hatchery chinook	4046	4767	6567	May 3	May 7	May 14	4	7.5	38.5
	Trucked hatchery chinook	4046	4767	6567	May 3	May 7	May 14	11	6.9	20.6

[a]Cumulative passage figures made relative to April 4 starting date-the latest test starting date since 1983.

issue because the effects of migration rate are confounded with time and place of release.). Three groups of size-graded hatchery coho were branded and released at Wapatox trap on April 25, 1986 --- a group in which fork length was greater than 160 mm (mean = 188), a group with randomly selected lengths (mean = 152) and a group with lengths all less than 140 mm (mean = 122). The large group migrated more rapidly than the random group and had a greater survival rate (see Table 32). The small group showed the lowest survival rate, but had the same median migration rate as the large group. There were, however, only four actual catches of small branded coho (with total passage estimated at five) and two were on the same day. The significance of the migration rate estimate for the small group is therefore questionable.

The effect of migration rate on survival is also illulstrated by three groups of random-sized wild spring chinook released at Wapatox in 1986. Two groups were released April 23 and one was released on May 8. The migration rates of the two earlier releases was nearly identical (2.5 and 2.7 mi/day, mean = 2.6 mi/day) as were the survival rates (25.4 and 26.0 percent, mean = 25.7 percent). The estimated migration rate for fish in the later release was 4.3 mi/day, about 1.6 times the mean figure for the earlier releases. The estimated survival of late-released fish, 38.9 percent, was also about 1.6 times the mean survival of the earlier releases (see Table 32). The greater survival rate for fish in the later release is probably attributable to the fact they

Table 32. Summary of run-timing, survival, and length at release and recapture of branded groups of wild spring chinook and hatchery coho released at Wapatox in 1986.

Group	Release dates	Median passage date	Migration rate (mi/day)	Number released	Passage to Prosser	Survival (percent)	Mean length at release (mm)	Mean length at recapture (mm)
Large Nile pond hatchery coho	04/25/86	05/12/86	5.8	267	18	6.7	188 (all > 160)	176
Random Nile pond hatchery coho	04/25/86	05/15/86	4.9	500	25	5.0	152 (random lengths)	154
Small Nile Pond hatchery	04/25/86	05/15/86	5.8	184	5	2.7	122 (all < 140)	139[a]
Random Nile pond hatchery coho	05/10/86	05/28/86	5.4	534	75	14.0	149	154[a]
Wild Naches River spring chinook	04/23/86	05/26/86	3.0	59	15	25.4	no data	114
Wild Naches River spring chinook	04/23/86	05/28/86	2.8	215	56	26.0	no data	123
Wild Naches River spring chinook	05/07/86	05/29/86	4.7	149	58	38.9	no data	124

[a]Significance level of difference between mean lengths at release and recapture = 0.05.

migrated more rapidly. The same stock and experimental procedures were employed in all three releases, the mean lengths at release were probably comparable, and the mean daily discharge at Prosser during outmigration of early and late releases was nearly identical — 2,502 and 2,451 cfs respectively. Presumably, fish in the later release consisted of advanced smolts with a more urgent migratory disposition. Their median travel time to Prosser was 21 days whereas the mean travel time for the earlier releases was 34 days. With 60 percent of the earlier groups' time of exposure to predators, one would expect the survival rate of the later group to be proportionately greater.

Effect of release size on survival. Three releases of branded coho at Wapatox in 1986 indicated that smaller smolts have a lower survival rate. Survival rate ranking for the three groupsreleased April 23 was the same as size ranking (see Table 32). Moreover, the mean length of coho released May 10 as sampled at Prosser was significantly greater than the mean length at release (t= 1.761, one-tailed test, 400 df). Together these facts suggest positive size selection for migrating smolts.

6.1.4 WAPATOX SMOLT TRAP

Wapatox smolt trap began operation March 22 when the screens were installed in the Wapatox Diversion Canal. A monthly summary of the estimated number of spring chinook and rainbow-steelhead outmigrants in 1985 and 1986 is presented in Table 33. Estimated spring chinook smolt outmigration in April, May and June was 2,935, 3,902 and 765 fish, respectively. Estimated pre-smolt outmigration in July and August was 509 and 169. The estimated number of pre-smolts in September was 2,178 fish. Total estimated smolt outmigration past Wapatox in 1986 was 6,671 fish. This compares to an estimated outmigration of 41,511 spring chinook smolts in 1985. Two factors probably contribute to the marked decrease in the 1986 smolt outmigration. The first is the large number (59,800) of fall pre-smolt outmigrants observed in 1985. For a given brood year one would expect the spring smolt run to be smaller when the fall pre-smolt outmigration is high. The second factor is that stream discharge from March 4 through March 10, 1986 was much higher than was observed at the same time in 1985 (see Figure 24). The March freshet in 1986 may have caused an early outmigration which was not detected because the screens had not yet been installed in the canal. The mean daily discharge in 1985 prior to the opening of the trap was 518 cfs, whereas the mean discharge over the same period in 1986 was several times larger, with a peak discharge of 3,856 cfs. The spring freshet in 1985 began after the trap was opened, with the peak discharge of 2,800 cfs occurring three weeks into the season. It is thus

Table 33. Summary of monthly outmigration of spring chinook and rainbow-steelhead at Wapatox in 1985 and 1986.

Year	Species	April	May	June	July	August	September
1985	Spring chinook	38,786	2,823	323	193	140	4,941
1986	Spring chinook	2,925	3,902	765	509	169	2,178
1985	Rainbow-steelhead	3,224	1,969	964	44	140	570
1986	Rainbow-steelhead	1,507	6,317	772	175	169	625

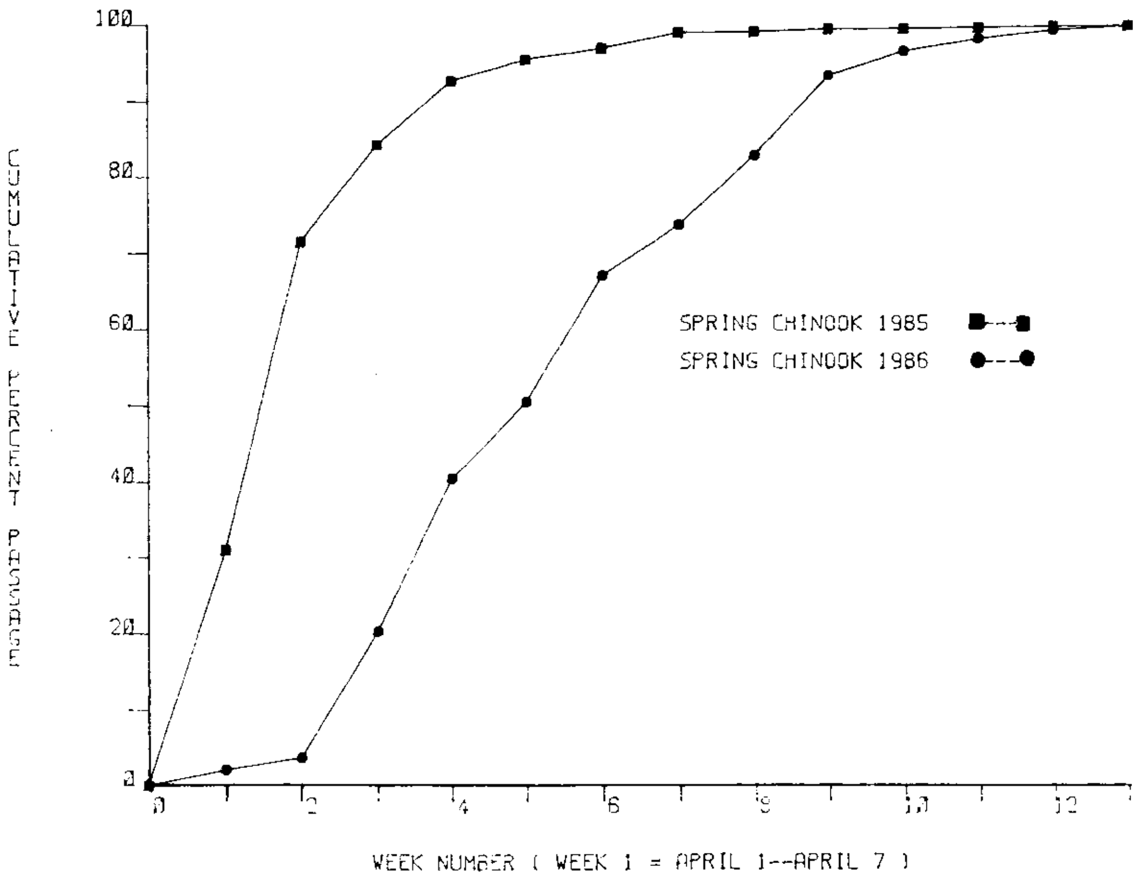


Figure 24. Cumulative percent passage of spring chinook smolts past Wapatox in 1985 and 1986.

unlikely that significant outmigration in 1985 occurred before the start of trap monitoring. If the 1986 freshet caused a substantial undetected outmigration of spring chinook smolts, then the larger count in 1985 could be at least partially attributable to a larger proportion of the 1985 run being monitored.

The estimated weekly catch of spring chinook and rainbow-steelhead is presented in Table 34. The period of highest spring chinook smolt movement occurred between April 15 and May 5 when 61% outmigrated. The 1986 outmigration appears to be later than the 1985 outmigration. Dates of median passage were April 9 in 1985 and May 5 in 1986. Figure 25 presents the cumulative percent passage (adjusted for different starting dates) of spring chinook smolts in 1985 and 1986. For both years it appears that trap monitoring started after smolt outmigration began. It is obvious that the greater the proportion of the smolt run missed, the later will be the observed date of median passage. Therefore, the true dates of median passage may be somewhat earlier than were actually observed.

Monthly size distributions of spring chinook smolts are presented in Figures 26 and 27. Mean monthly lengths in April, May, and June were 93, 95, and 111 mm, respectively. The mean lengths of pre-smolts in July, August, and September was 83 and 85 mm.

The estimated outmigration of steelhead smolts in 1986 was 7,008 fish. This was about 900 more smolts than in 1985. The period of median passage occurred May 13 - 19 in 1986, compared to April 22 - 28 in 1985. As was the case with spring chinook, outmigration in 1986 was later than in 1985.

Table 34. Estimated weekly catches of spring chinook and rainbow-steelhead at Wapatox, 1986; based on P.D.S. (percent discharge into canal).

Date	Chinook smolt	Chinook pre-smolt	Rainbow-steelhead smolt	Rainbow-steelhead pre-smolt
3/22-24	10	0	0	40
3/25-31	240	56	9	99
4/1-7	141	19	0	51
4/8-14[a]	94	10	11	33
4/15-21	1,072	8	126	155
4/22-28	1,294	51	677	252
4/29-5/5	646	70	407	127
5/6-12	1,072	166	1,484	169
5/13-19	429	147	1,203	215
5/20-26	580	419	2,273	275
5/27-6/2	681	132	368	76
6/3-9	202	62	197	96
6/10-16	104	23	168	31
6/17-23	68	40	60	17
6/24-30	38	20	25	0
7/1-7	0	98	0	22
7/8-14	0	45	0	28
7/15-21	0	216	0	30
7/22-28	0	54	0	25
7/29-8/4	0	130	0	36
8/5-11	0	83	0	36
8/12-18	0	134	0	60
8/19-25	0	45	0	27
8/26-9/1	0	73	0	41
9/2-8	0	125	0	42
9/9-15	0	865	0	106
9/16-22	0	551	0	120
9/23-29	0	536	0	357
Totals	6,671	4,228	7,008	2,566

[a]Catch is an estimate since trap was inoperable for 2 days during this week.

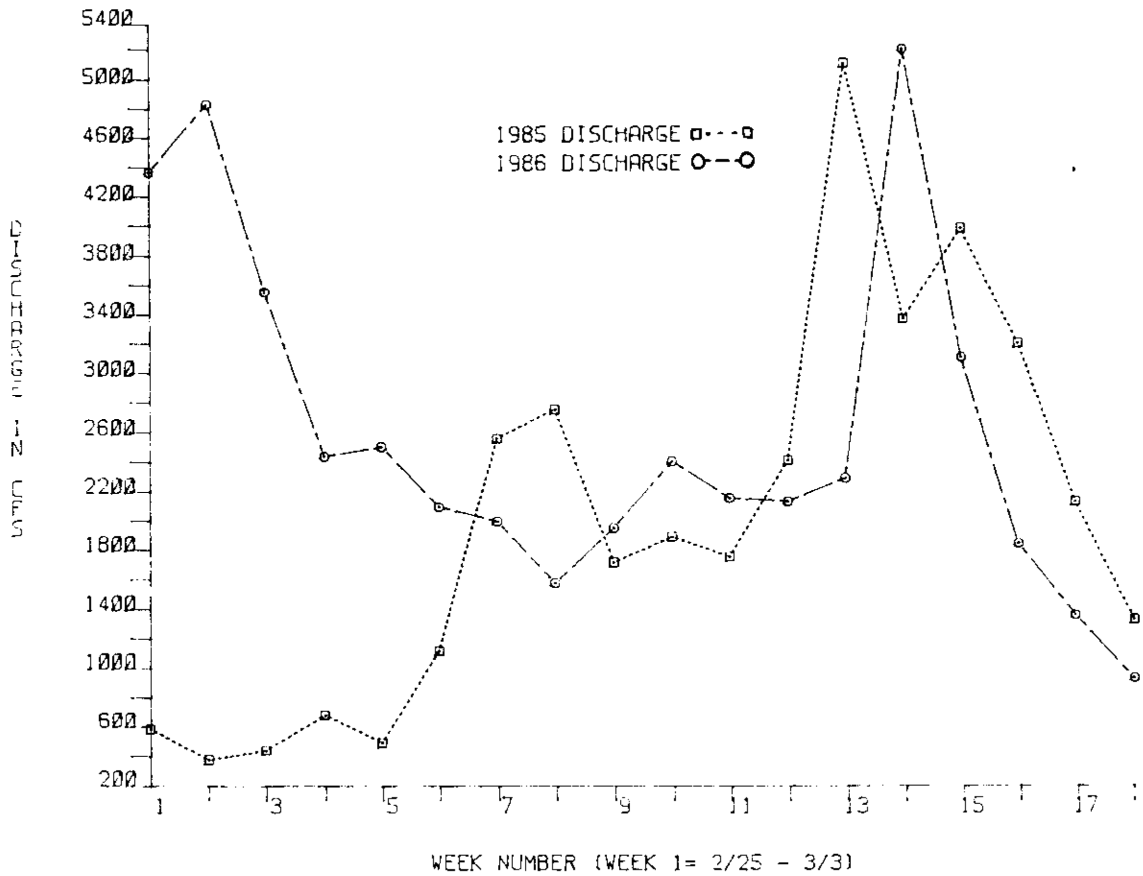


Figure 25. Mean weekly discharge (cfs) at Wapatox for the period February 25 through June 30 in 1985 and 1986.

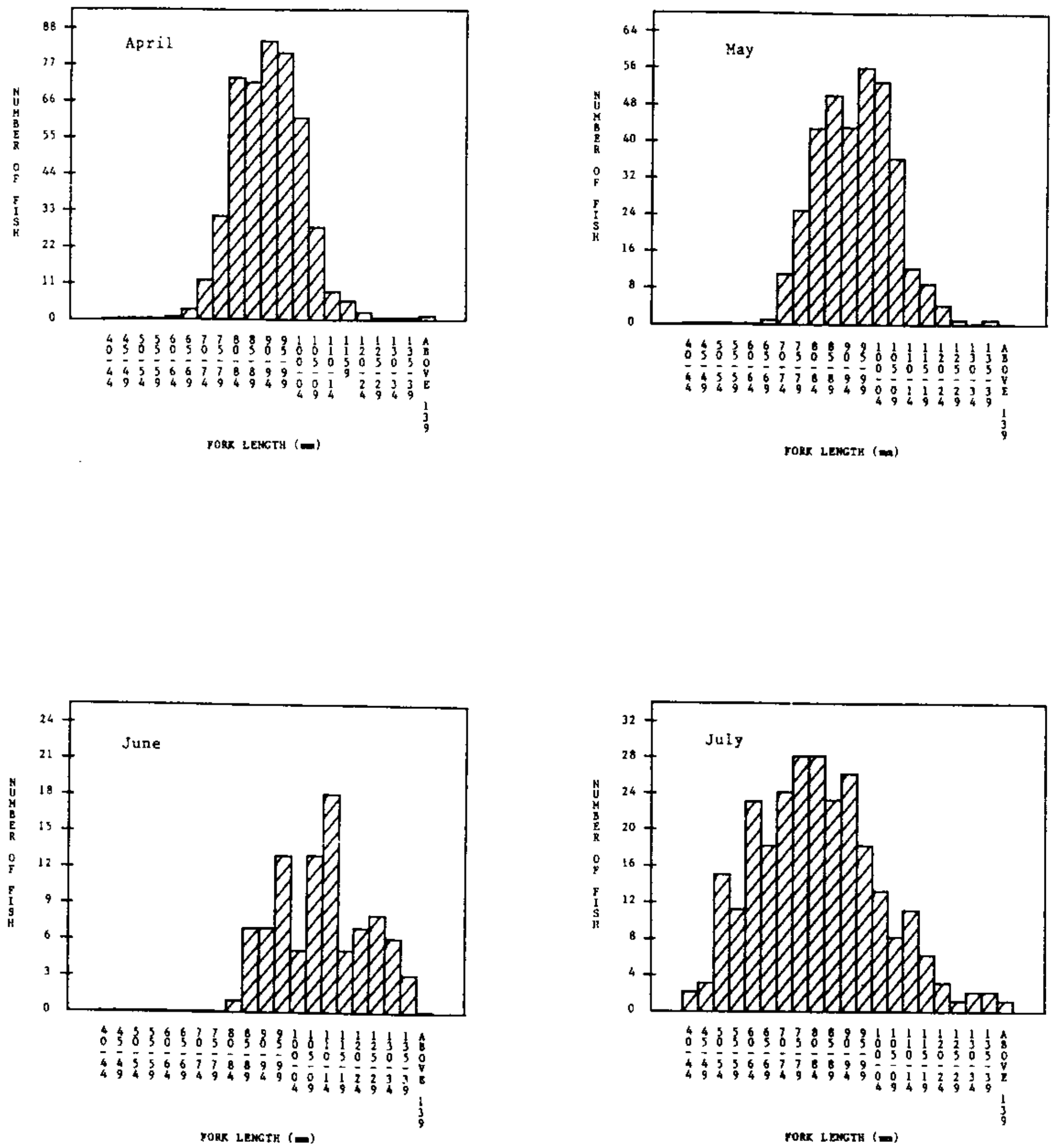


Figure 26. Monthly size distribution of spring chinook (excluding young-of-the-year April through June) in April, May, June and July, 1986.

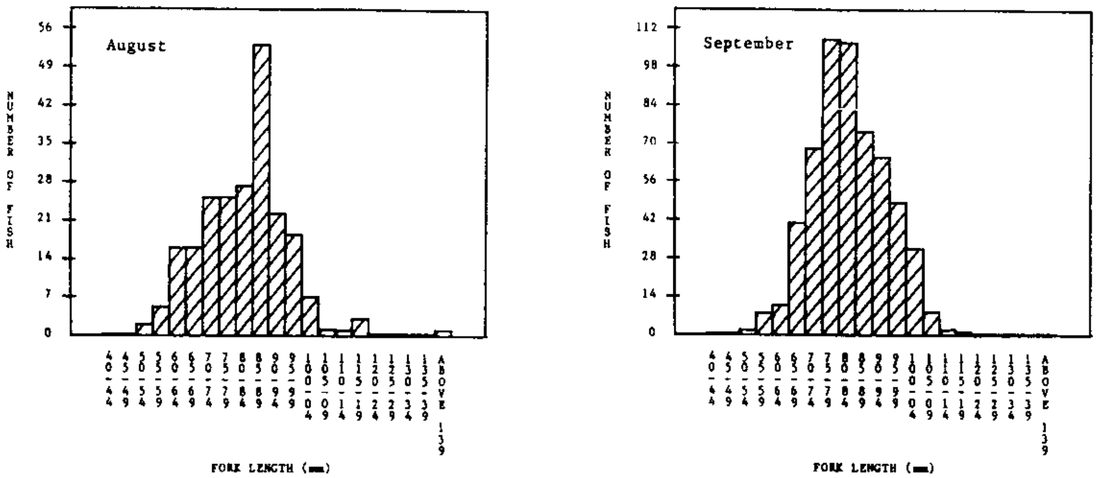


Figure 27. Monthly size distribution of spring chinook in August and September, 1986.

6.1.5 LOST CREEK PONDS

Table 35 presents the weekly catch of spring chinook in the inflow trap. A total of 1,523 spring chinook fry were captured. The actual number of spring chinook that entered the ponds was higher, because not all fry could be enumerated during periods of high river discharge when trap was not fish-tight. The greatest period of fry immigration was April 29 through June 2, when 63% of the immigrants were enumerated. The time of peak fry immigration was probably a function of two factors. The first was that peak fry emergence occurred at the same time, so there was an abundance of newly-emerged fry in the river. The second was that mean daily discharge was high (1,634 cfs) at this time, causing many newly-emerged fry to be displaced downstream and become entrained in the diversion ditch.

Table 36 presents a summary of spring chinook brand releases and recoveries for each month. The total number of branded fry released was 1,352, while the total number recaptured was 74 fish. The mean percent recaptured for all brand groups was 5.5%. Recapture percentages ranged from 0% for the August group to 9.9% for the July group. These results seem to suggest that the majority of spring chinook fry are rearing throughout the summer in these ponds.

The low number of recaptures could be the result of high mortality in the ponds. Efforts to evaluate survival rates of the various groups proved unsuccessful. However it is believed that the survival rate of rearing spring chinook in these ponds is

Table 35. Weekly catches of spring chinook at Lost Creek ponds inlet trap, 1986.

Date	Chinook fry	Chinook smolt/parr
3/4-10	29	0
3/11-17	48	0
3/18-24	15	0
3/25-31	34	0
4/1-7	22	0
4/8-14	88	0
4/15-21	33	0
4/22-28	79	0
4/29-5/5	118	0
5/6-12	253	1
5/13-19	257	0
5/20-26	195	0
5/27-6/2[a]	143	3
6/3-9[b]	14	0
6/10-16	40	0
6/17-23	5	0
6/24-30	6	0
7/1-7	47	0
7/8-14	25	0
7/15-21	7	0
7/22-28[c]	—	—
7/29-8/4[d]	19	0
8/5-11	7	0
8/12-18	8	0
8/19-25	10	0
8/26-9[a]	16	0

[a]Trap not fish tight 7 days due to high water.
[b]Trap not fish tight 2 days due to high water.
[c]No inflow to pond all 7 days.
[d]No inflow to pond for 1 day.

Table 36. Summary of spring chinook fry brand releases and brand recoveries at Lost Creek ponds, 1986.

Month	Brand code	No. released	Brands recaptured LA..	RA..	LP..	RP..
March	LA..	108	3	—	—	—
April	LA..	233	7	—	—	—
May	RA..	734	3	16	—	—
June	LP..	173	2	20	2	—
July	RP..	91	0	8	4	9
August	RP..	13	0	0	0	0

probably higher than in the mainstem river because of good instream cover, an abundant food supply, and few piscivorous fish.

The mean fork length of fry captured in the inflow trap during March through June range from 36 mm to 39 mm, indicating that these fish were newly emerged. Mean monthly growth rates were determined for the May group. Their mean fork length at release into the upper pond was 37 mm, and their mean fork length when recaptured in the outlet trap in May, June, and July was 38 mm, 48 mm and 51 mm, respectively. Thus, mean growth increments in May, June and July were 1 mm, 10 mm and 3 mm.

A total of 714 spring chinook smolts migrated from the ponds between February 28 and June 30, indicating that spring chinook were over-wintering in the ponds. Ninety-seven percent of the smolts had emmigrated by March 18. Their overall mean fork length was 94 mm. The larger smolts emmigrated first. Mean fork length through March 7 was 101 mm, and declined to 84 mm for the balance of the season.

In summary, it appears that spring chinook fry enter the ponds shortly after emergence and rear there continuously until outmigrating the following spring as smolts.

These results suggest that the Lost Creek ponds provide favorable habitat for spring chinook juveniles from the stage of newly emergent fry through smolt. A similar situation may exist in another pond near the town of Naches. Preliminary investigations indicate juvenile spring chinook are rearing in a cattle pond on a small diversion from the Naches River (John Easterbrooks, personal communication, 1986). These observations suggest that a possible method of increasing the freshwater survival of wild spring chinook would be the construction of similar ponds along the Yakima and Naches Rivers.

6.1.6 ADULT RETURNS

In 1986 a total of 8,563 adult and 349 jack spring chinook salmon returning to the Yakima River were counted at Prosser fish ladder at RM 48 (Tables 37 and 38). This gives a total of 8,912 salmon returning to Prosser Dam (Table 39). The raw daily fish counts for Prosser Dam are presented in Appendix Tables D.1 through D.4. The mean dates of passage were May 18 and May 26 for adults and jacks respectively. An additional 530 fish were estimated to have been caught in the Yakima River subsistence dipnet fishery below Horn Rapids and Prosser Dams (Table 40). Therefore, total return to the Yakima system was 9,442 spring chinook salmon. This was the largest return of spring chinook salmon to the Yakima River in 29 years (Table 41).

Spring chinook were counted at Roza Dam from May 13 to September 30, 1986. Passage at Roza Dam was 2,967 adult and 284 jack spring chinook for a total of 3,251 fish (Tables 42, 43, and 44). An additional 810 fish were harvested between Prosser and Roza Dams in the subsistence dipnet fishery (Table 40). Daily raw counts of fish passage at Roza Dam are presented in Appendix Tables D.5 through D.8. The median dates of passage at Roza Dam were June 6 and June 23 for spring chinook adults and jacks respectively.

A summary of adult and jack returns to each of the dams, harvest below and above Prosser, and the number of fish available to spawn in the Yakima and Naches Rivers is presented in Table 45.

Table 37. Weekly adult spring chinook passage at Prosser Dam, 1986.
(1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
3	423	83	0.0097	83	0.0097
4	430	337	0.0394	420	0.0491
5	507	994	0.1162	1414	0.1652
6	514	1214	0.1419	2628	0.3071
7	521	2928	0.3422	5556	0.6493
8	528	141	0.1333	6697	0.7826
9	604	310	0.0362	7007	0.8189
10	611	807	0.0943	7814	0.9132
11	618	225	0.0263	8039	0.9395
12	625	275	0.0321	8314	0.9716
13	702	75	0.0088	8389	0.9804
14	709	76	0.0089	8465	0.9892
15	716	76	0.0089	8541	0.9981
16	723	14	0.0016	8555	0.9998
17	730	2	0.0002	8557	1.0000

Mean date: May 18

Table 38. Weekly jack spring chinook passage at Prosser Dam, 1986.
(1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
6	514	3	0.0086	3	0.0086
7	521	145	0.4155	148	0.4241
8	528	72	0.2063	220	0.6304
9	604	24	0.0688	244	0.6991
10	611	59	0.1691	303	0.8682
11	618	9	0.0258	312	0.8940
12	625	18	0.0516	330	0.9456
13	702	11	0.0315	341	0.9771
14	709	2	0.0057	343	0.9828
15	716	4	0.0115	347	0.9943
16	723	1	0.0029	348	0.9971
17	730	1	0.0029	349	1.0000

Mean date: May 26

Table 39. Weekly total spring chinook passage at Prosser Dam, 1986 .
(1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
3	423	83	0.0093	83	0.0093
4	430	337	0.0378	420	0.0472
5	507	994	0.1116	1414	0.1588
6	514	1217	0.1366	2631	0.2954
7	521	3073	0.3450	5704	0.6405
8	528	1313	0.1474	7017	0.7879
9	604	234	0.0263	7251	0.8142
10	611	866	0.0972	8117	0.9114
11	618	236	0.0265	8353	0.9379
12	625	291	0.0327	8644	0.9706
13	702	86	0.0097	8730	0.9802
14	709	78	0.0088	8808	0.9890
15	716	80	0.0090	8888	0.9980
16	723	15	0.0017	8903	0.9997
17	730	3	0.0003	8906	1.0000

Mean date: May 19

The length frequency distribution of spring chinook salmon returning to the American, Naches and the upper Yakima Rivers is presented in Figures 28, 29 and 30. As can be seen from these figures, there is an apparent break between the four and five year old spawners. The American River appears to be mainly larger five year old fish (only 15%<680mm); the Naches system has a bimodal distribution (60%> 680mm and 40%<680mm) and the upper Yakima appears to be all smaller four year old fish (only 2%>680mm). Otoliths and scales were also collected on spawner ground surveys and will be analysed and used to separate age classes in various system subareas. The determination of age classes of returning adults in various subareas may be an important genetic factor that should be considered if wild stocks are to be used for enhancement efforts in other areas of the Yakima Basin.

Table 40. YIN Yakima River spring chinook fishery, 1981 - 1985.

	Estimated chinook	Horn Rapids harvests		Prosser harvests		Sunnyside harvests		Wapato harvests		Total harvests	
Year	run size	CH	SH	CH	SH	CH	SH	CH	SH	CH	SH
1981	1,334	0	0	49	2	137	1	30	0	216	3
1982	1,686	10	0	78	0	241	11	105	2	434	13
1983	1,324	0	0	72	1	9	11	3	0	84	16
1984	2,677	3	0	116	4	122	18	48	3	289	25
1985	4,529	54	0	267	3	61	0	483	21	865	24
81-84 Average	1,775	3	0	79	2	127	10	47	1	256	14

Table 41. Estimated spring chinook runs to the Yakima River Basin, 1957-1986.

Year	Total redds[a] Naches	Total redds[a] Yakima	Total	Escapement[b]	Harvest[c]	Total run
1957	764	1216	1980	4752	7913	12665
1958	284	531	815	1956	4401	6357
1959	306	255	561	1346	3464	4810
1960	126	184	310	744	3668	4412
1961	166	175	341	818	5044	5862
1962	153	76	229	550	4185	4735
1963	185	—	—	—	2992	—
1964	50	81	131	314	3241	3555
1965	53	90	143	343	1763	2106
1966	95	32	127	305	4800	5105
1967	58	97	155	388	3195	3583
1968	25	61	86	206	2430	2636
1969	50	309	359	862	618	1480
1970	48	23	71	170	1512	1682
1971	—	97	—	—	1232	—
1972	55	101	156	374	480	854
1973	28	41	69	166	3221	3387
1974	30	40	70	168	1748	1916
1975	—	104	—	—	600	—
1976	35	108	143	343	—	—
1977	10	121	131	314	—	—
1978	95	308	403	967	—	—
1979	153	86	239	574	—	—
1980	113	353	466	1118	106	1224
1981	172	294	466	1118	216	1334
1982	54	573	626	1252	434	1686
1983	83	360	443	1240	84	1324
1984	220	634	854	2050	289	2677[d]
1985	427	951	1378	3582	865	4527[d]
1986	1298	1780	3078	7387	1300	8687

[a] Redd counts for 1957-1961 are total redd counts from Major and Mighell (1969). For 1962-1980 the counts are index counts from WDF or YIN coordinated surveys. Index counts in this time period were expanded by 1.8 and 2.5 for the upper Yakima and Naches systems, respectively. (Expansion factors were derived from the ratio of index counts to total counts for the respective systems. Total counts were from the Major and Mighell study and from the 1981-1984 surveys.) For 1981-1984 the counts are total redd counts from USFWS, YIN, and WDF cooperative surveys.

[b] Based on Roza Dam counts the number of fish per redd has averaged 2.4 in the upper Yakima since 1982. Historical escapement for 1958 to 1981 was therefore estimated as the total redd count multiplied by 2.4. For 1982 to 1984 the actual number of fish per redd was used to expand the total redd count.

[c] 1957-1975 WDF tribal harvest estimates; 1980-1985 YIN tribal harvest estimates. All harvest estimates are for the Yakima River only.

[d] Total run estimates for 1984 and 1985 are the sum of the Prosser Dam counts and the estimated harvests below Prosser Dam.

Table 42. Weekly adult spring chinook passage at Roza Dam, 1986. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
3	521	219	0.0738	219	0.0738
4	528	576	0.1941	795	0.2679
5	604	439	0.1480	1234	0.4159
6	611	383	0.1291	1617	0.5450
7	618	241	0.0812	1858	0.6262
8	625	302	0.1018	2160	0.7280
9	702	164	0.0553	2324	0.7833
10	709	128	0.0431	2452	0.8264
11	716	71	0.0239	2523	0.8504
12	723	122	0.0411	2645	0.8915
13	730	80	0.0270	2725	0.9184
14	806	87	0.0293	2812	0.9478
15	813	17	0.0057	2829	0.9535
16	820	15	0.0051	2844	0.9585
17	827	30	0.0101	2874	0.9687
18	903	58	0.0195	2932	0.9882
19	910	13	0.0044	2945	0.9926
20	917	4	0.0013	2949	0.9939
21	924	13	0.0044	2962	0.9983
22	930	5	0.1117	2967	1.0000

Mean date: June 6

Table 43. Weekly jack spring chinook passage at Roza Dam, 1986 (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
3	521	27	0.0951	27	0.0951
4	528	95	0.3345	122	0.4296
5	604	9	0.0317	131	0.4613
6	611	16	0.0563	147	0.5176
7	618	15	0.0528	162	0.5704
8	625	24	0.0845	186	0.6549
9	702	17	0.0599	203	0.7148
10	709	17	0.0599	220	0.7746
11	716	16	0.0563	236	0.8310
12	723	13	0.0458	249	0.8768
13	730	19	0.0669	268	0.9437
14	806	13	0.0458	281	0.9894
15	813	0	0.0000	281	0.9894
16	820	0	0.0000	281	0.9894
17	827	0	0.0000	281	0.9894
18	903	1	0.0035	282	0.9930
19	910	0	0.0000	282	0.9930
20	917	0	0.0000	282	0.9930
21	924	1	0.0035	283	0.9965
22	930	1	0.0035	284	1.0000

Mean date: June 23

Table 44. Weekly total spring chinook passage at Roza Dam, 1986
(1) Index week number; (2) Week-ending date; (3) Weekly passage;)
(4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
3	521	246	0.0756	246	0.0750
4	528	671	0.2063	917	0.2820
5	604	448	0.1378	1365	0.4197
6	611	399	0.1227	1764	0.5424
7	618	256	0.0787	2020	0.6212
8	625	326	0.1002	2346	0.7214
9	702	181	0.0557	2527	0.7771
10	709	145	0.0446	2672	0.8216
11	716	87	0.0268	2759	0.8484
12	723	144	0.0443	2903	0.8927
13	730	90	0.0277	2993	0.9204
14	806	100	0.0308	3093	0.9511
15	813	17	0.0052	3110	0.9563
16	820	15	0.0046	3125	0.9609
17	827	30	0.0092	3155	0.9702
18	903	60	0.0185	3215	0.9886
19	910	13	0.0040	3228	0.9926
20	917	4	0.0012	3232	0.9938
21	924	14	0.0043	3246	0.9982
22	930	6	0.0018	3252	1.0000

Mean date: June 6

The spring chinook redd counts from 1981 to 1986 are presented in Table 46. These counts were not part of the data collected on the present spring chinook study but are important for estimates of survival through various life stages and are included in this report for that reason.

Upper Yakima Surveys: A total of 1,793 redds were reported from surveys on the upper Yakima. A total of 1,471 were above Roza Dam and an additional 321 were discovered in the area between Roza Dam and Selah Bridge. One redd was found near the city of Yakima. It is believed that there were more than the reported 321 redds below Roza Dam but surveys conducted on 10/10 and 10/16 were inconclusive due to silt laden water being released from Roza Dam.

The number of fish per redd was calculated by dividing escapement above Roza by the number of redds deposited above Roza.

Table 45. Total spring chinook salmon return to the Yakima River and to the spawning grounds in 1986.

Return to Prosser	
Adults to Prosser Dam	8,563
Jacks to Prosser Dam	349
Total run to Prosser	8,912
Harvest below Prosser	530
Total run to the river	9,442
Return to Roza	
Adults to Roza Dam	2,967
Jacks to Roza Dam	284
Total Run to Roza	3,251
Hatchery fish taken at Roza	30
Total number available to spawn in upper Yakima	3,221
Harvest between Prosser and Roza	810
Fish spawning between Roza and Prosser[a]	706
Number of fish available to spawn in the Naches River[b]	4,145

[a]A total of 321 redds were discovered in the area between the Selah Bridge and Roza Dam. It was calculated that there are 2.2 fish per redd in the Yakima giving a total of 706 fish spawning below Roza Dam in the Yakima River.

[b]Calculated as number of fish counted at Prosser, minus the harvest between Prosser and Roza minus the fish spawning in the Yakima below Roza minus the number of fish counted at Roza ladder.

The number of chinook escaping past Roza was 3,251; the number of redds was 1,471. The resulting statistic was 2.2 fish per redd. There is no accounting for pre-spawning mortality by this method. Consequently, 2.2 does not necessarily reflect the average number of fish observed on a redd on the spawning grounds.

Naches Surveys: There were a total of 1,313 redds found on the Naches River in 1986. This represents the highest redd count on the Naches system since 1957. Substantial increases were observed in virtually all established spawning areas.

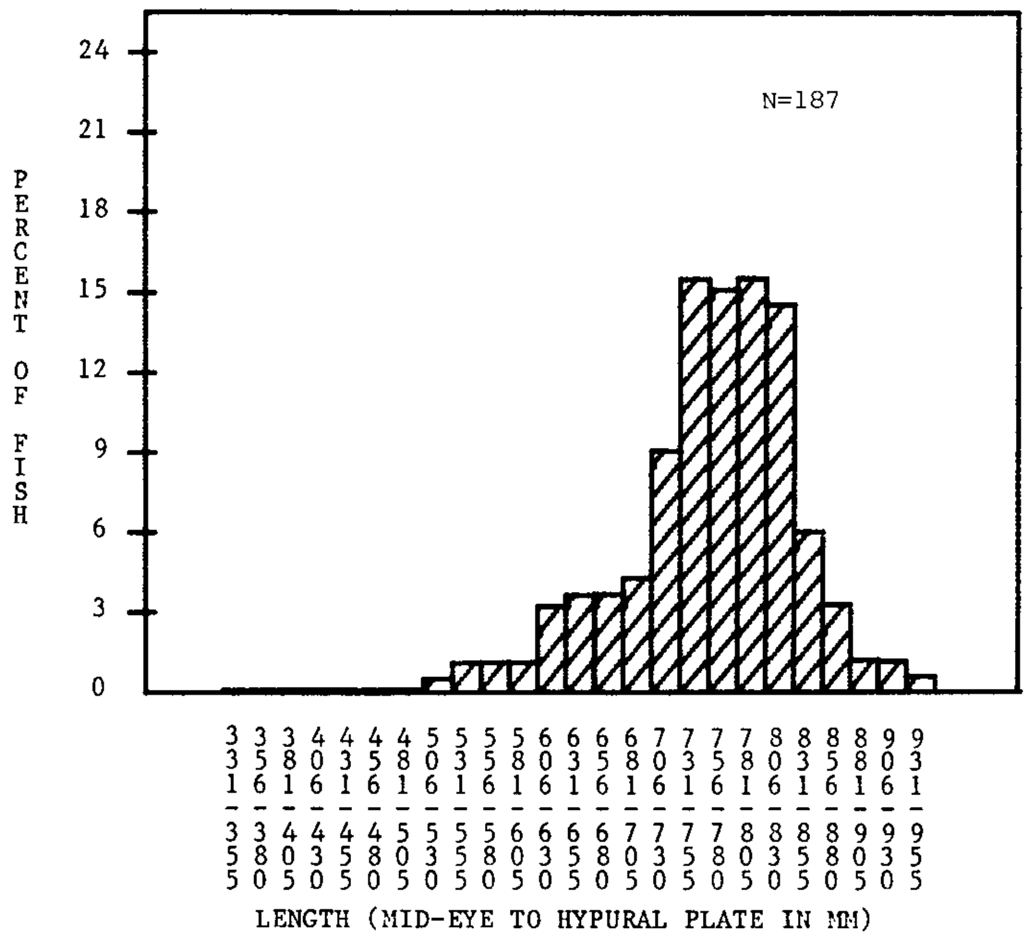


Figure 28. Length frequency distribution of spring chinook spawners in the American River, 1986.

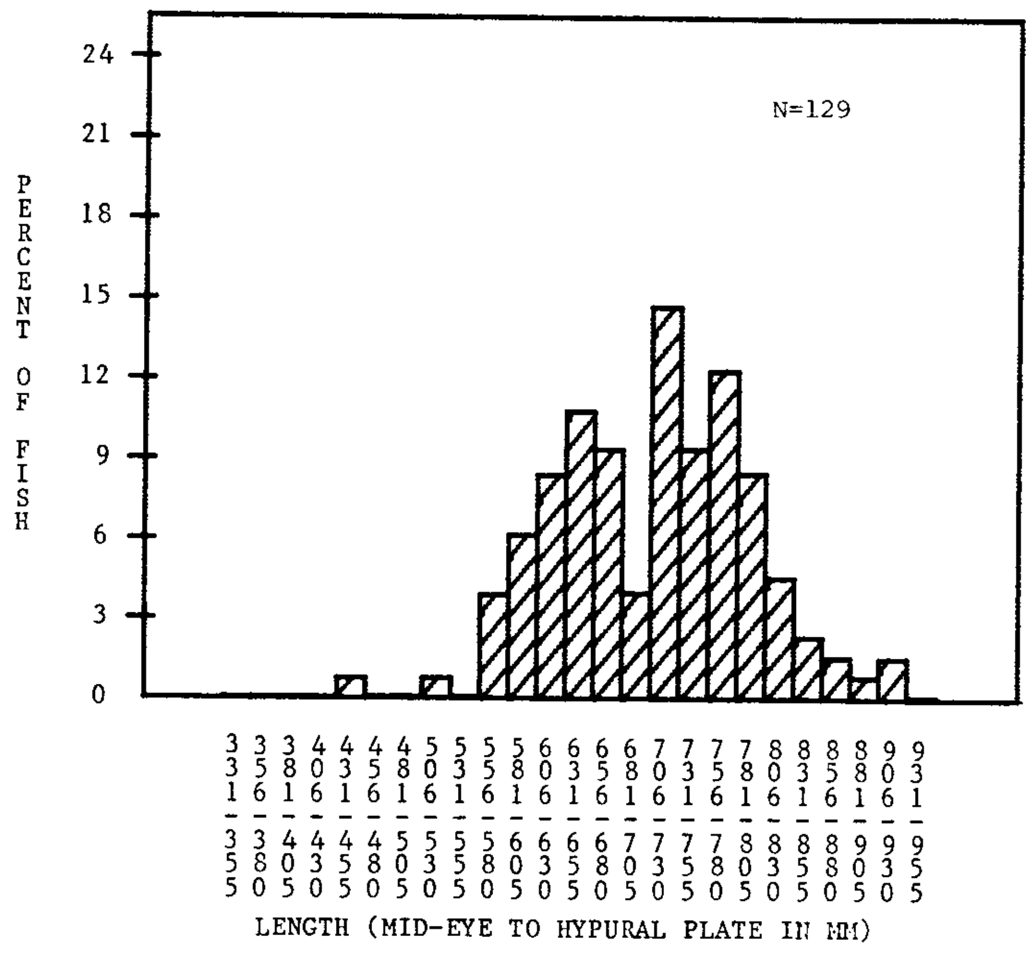


Figure 29. Length frequency distribution of spring chinook spawners in the Naches River, 1986.

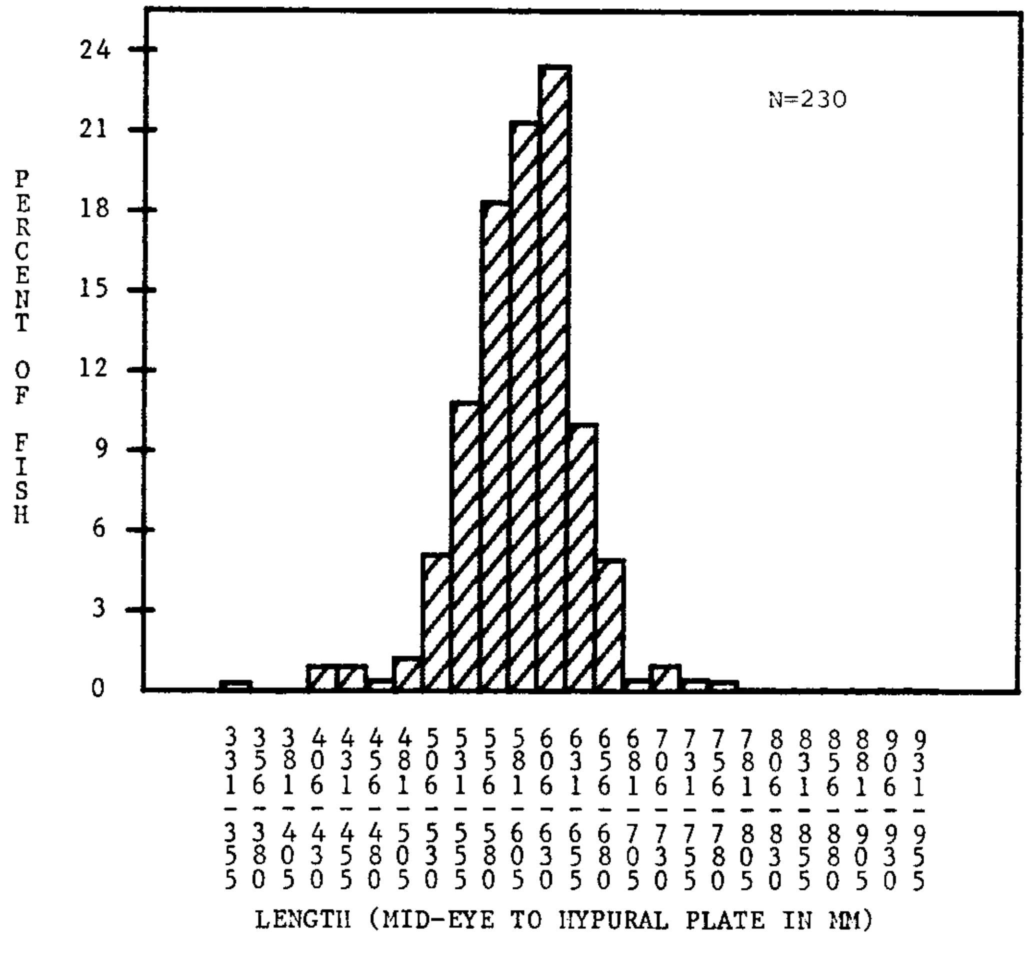


Figure 30. Length frequency distribution of spring chinook spawners in the Yakima River, 1986.

Table 46. Yakima River Basin spring chinook redd counts, 1981 - 1986.

	1981	1982	1983	1984	1985	1986
Upper Yakima system						
Easton	126	204	104	302	322	352
Game Ramp	35	92	32	66	77	127
Freeway Bridge	30	159	87	145	137	352
S. Cle Elum Bridge	39	80	77	67	118	253
Teanaway Reach	2	8[a]	20	9	22[a]	118
Ellensburg Town Ditch	5	—	25	11	17	
Cle Elum River	57	30	15	31	153	77
Teanaway River	0	0	0	0	3	0
Miscellaneous	—	—	—	3[b]	102[c]	514
Subtotal	294	573	360	634	951	1793
Naches system						
American River	72	11	36	72	141	464
Bumping River	20	6	11	26	74	196
Little Naches River	16	12	9	41	44	110
Rattlesnake Creek	0	2	4	24	11	17
Naches River	64	23	23	57	157	526
Subtotal	172	54	83	220	427	1313
Basin total	466	627	443	854	1378	3106

[a]Teanaway River to Thorp Bridge
[b]Manastash Creek (rm 0.0-4.6)
[c]Roza Dam to Selah Bridge - 321 redds; Thorp Bridge to KOA - 110 redds; KOA to Wilson Creek - 64 redds; Wilson Creek to Burbank Creek - 18 redds; and downtown Yakima - 1 redd.

6.1.7 ESTIMATES OF SURVIVAL THROUGH VARIOUS LIFE STAGES

6.1.7.1 Egg to Fry:

Survival from egg to fry was discussed extensively in the survival to emergence section of this report. The survival from egg to emergent fry was calculated to be 56.7% from eight redds that were successfully capped in 1986.

Total egg deposition in the Yakima system from 1981 to 1986 is presented in Table 47. Total egg deposition was calculated as the sum of three subareas: the upper Yakima, the American River, and the remaining Naches system due to different mean size of females in each of these areas. The mean fecundity as calculated from the length fecundity model and the mean length of females measured in each subarea in 1985 was 3,908 eggs/female in the upper Yakima, 6,198 eggs/female in the American River and 5,150 eggs/female in the rest of the Naches system. This length fecundity model predicts different egg numbers than the model used by Major and Mighell (1969) which was developed by Galbreath and Ridenhour (1964). Their model was based on all stocks of spring, summer, and fall chinook that were collected in the lower Columbia River. If only the data for spring chinook from Galbreath and Ridenhour's model is used with the lengths reported by Major and Mighell (1969) the fecundity estimates would be closer to those reported in the current study.

The total number of fry produced from the egg deposition in 1981 to 1986 is reported in Table 48. This estimate is based on the current 59.6% egg to fry survival rate which is the mean of the 62.5% estimate in 1985 and the 56.7% from 1986.

Table 47. Total estimated egg deposition in the Yakima Basin for 1981 to 1986.

Brood year	Subarea	Number of redds	Eggs/redd	Total
1981	American River	72	6,198	446,256
	Naches (other)	100	5,150	515,000
	Yakima (upper)	294	3,908	1,148,952
	Total	466		2,110,208
1982	American	11	6,198	68,178
	Naches	43	5,150	221,450
	Yakima	573	3,908	2,239,284
	Total	628		2,528,912
1983	American	36	6,198	223,128
	Naches	47	5,150	242,050
	Yakima	360	3,908	1,406,880
	Total	443		1,872,058
1984	American	72	6,198	446,256
	Naches	148	5,150	762,200
	Yakima	634	3,908	2,477,672
	Total	854		3,686,128
1985	American	141	6,198	873,918
	Naches	286	5,150	1,472,900
	Yakima	951	3,908	3,716,508
	Total	1,378		5,189,408
1986	American	464	6,198	2,875,872
	Naches	850	5,150	4,377,500
	Yakima	1,796	3,908	7,018,768
	Total	3,110		14,272,140

Table 48. Estimated fry production from eggs deposited in the Yakima Basin from 1981 to 1986.

Brood year	Total egg deposition	% survival	Total fry
1981	2,110,208	59.6	1,257,684
1982	2,528,912	59.6	1,507,232
1983	1,872,058	59.6	1,115,747
1984	3,686,128	59.6	2,196,932
1985	5,189,408	59.6	3,092,887
1986	14,272,140	59.6	8,506,195

6.1.7.2 Egg to Smolt:

The egg to smolt (S_{es}) survival was calculated as the number of smolts estimated to outmigrate past Prosser divided by the total egg deposition for their year class as calculated in Table 47. The egg to smolt survival from egg deposition for the brood years 1981 to 1984 and corresponding smolt outmigration years of 1983 to 1986 are presented in Table 49.

This mean percent survival from egg to smolt of 5.1% is much lower than the 10.7% (range from 5.4 to 16.4) reported by Major and Mighell (1969). This may possibly be due to an overestimation of the smolt outmigration by Major and Mighell due to their assumption that an equal volume of water over the dam contains an equal number of fish as water down the irrigation canal. A reevaluation of their data in our final report will attempt to resolve this difference. Bjornn (1978) evaluated natural production of spring chinook in the Lemhi River, Idaho, and over an 8-year period found that survival from egg to migrant smolt averaged 9.8% (range 4.0% to 15.9%). This is also much higher than the three year mean of 5.1% we found. He considered the level of

Table 49. Egg to smolt survival for 1981 to 1984 brood years in the Yakima Basin.

Brood year	Egg deposition	Outmigrating smolts	Percent survival
1981	2,110,208	136,102	6.5%
1982	2,528,912	123,732	4.9%
1983	1,872,058	83,614	4.5%
1984	3,686,128	169,077	4.6%
Mean	2,549,327	128,131	5.1%

spawning escapements to the upper Lemhi River low during the study years, thus underseeding may have resulted in maximum survival rates for juvenile chinook in that system.

Several other studies conducted on mid-Columbia tributaries had survival rates similar to those observed in the current study. In the Deschutes River, Oregon Johasson and Lindsay (1983) found an average egg-to-migrant survival rate of 3.5 percent (range 2.3% to 5.5%) for their spring chinook smolts. These were primarily yearling spring migrants but also included fall (age 0) migrants. An egg-to-migrant survival rate of 5.2% (range 3.6% to 6.7%) was found for spring chinook in the John Day River, Oregon, (Lindsay et al., 1981). These percentages were based on yearling spring migrants only.

6.1.7.3 Fry to Smolt:

An estimate of the survival from fry to smolt (S_{fs}) based on the fry production (Table 48) and smolt outmigration at Prosser for the brood years of 1981 to 1984 is reported in Table 50.

Table 50. Estimated survival from fry to smolt in the Yakima Basin for brood years 1981 to 1984.

Brood year	Fry produced	Smolt out-migration	Percent survival
1981	1,257,684	136,102	10.3%
1982	1,507,232	123,732	7.6%
1983	1,115,747	83,614	7.1%
1984	2,196,932	169,077	7.7%
Mean	1,519,399	128,131	8.2%

6.1.7.4 Smolt to Adult:

The smolt to adult (S_{sa}) survival based on the 1983 smolt outmigration estimated at Prosser and the 1984 return of jacks (3 year old fish), the 1985 return of four year old adults, and the 1986 return of five year old adults to the Yakima River is reported in Table 51. It was estimated that 6,012 wild three, four, and five year old fish returned from an estimated smolt outmigration of 135,548 fish in 1983.

The smolt to adult (S_{sa}) based on the 1984 smolt outmigration estimated at Prosser and the 1985 return of jacks and the 1986 return of four year old adults to the Yakima River is reported in Table 52.

This estimated rate of survival from smolt to adult is also subject to error due to our estimation of total outmigration. We are quite confident in the smolt outmigration estimation procedure for Prosser (Section 6.1.3). However, from the recent

Table 51. Estimation of smolt to adult survival of the 1983 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	3,783
plus adult harvest below Prosser	321
Total return of adult (4's + 5's) to system	4,104
Adults to Roza[a]	2,125
plus 237 (spawning below Roza)[b]	237
plus 361 (harvest above Prosser)[c]	361
Total adults to Yakima[d]	2,723
Adults to Naches[e]	1,198
plus 183 (harvest above Prosser)[f]	183
Total adults to Naches	1,381
times 50% (4 year old fish)[h]	691
Total four year old returns to system	3,414
plus jacks that returned in 1984	248
plus five year old returns in 1986[h]	2,440
Total 3 and 4 year old returns	6,102
minus hatchery fish	90
Total wild 3 and 4 year old returns	6,012
Wild smolts outmigrating in 1983	135,548
Survival $(S_{sa}) = \frac{6,102}{135,548} =$	4.4%

[a]Total adults counted at Roza fish ladder.
[b]Spring chinook calculated to spawn in Yakima River below Roza Dam from 91 redds at 2.6 fish/redd = 237 fish.
[c]Estimate of percentage of 544 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.3% of adult run returning to the Yakima and 33.7% to Naches.
[d]Estimated that 100% of the adults in the Yakima are four year old fish. [e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.
[f]Estimate of percentage of 544 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.7%).
[g]Estimated that 50% of the adults in the Naches system are four year old fish.
[h]From Table 52.

Table 52. Estimation of smolt to adult survival of the 1984 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	8,563
plus adult harvest below Prosser	530
Total return of adult (4's + 5's) to system	9,093
Adults to Roza[a]	2,967
plus 237 (spawning below Roza)[b]	706
plus 361 (harvest above Prosser)[c]	540
Total adults to Yakima[d]	4,213
Adults to Naches[e]	4,610
plus 183 (harvest above Prosser)[f]	270
Total adults to Naches	4,880
times 50% (4 year old fish)[g]	2,440
Total four year old returns to system	5,163
plus jacks that returned in 1984	423
Total 3 and 4 year old returns	5,586
minus hatchery fish	30
Total wild 3 and 4 year old returns	5,556
Wild Smolts outmigrating in 1984	123,732
Survival $(S_{sa}) = \frac{5,556}{123,732} =$	4.5%

[a]Total adults counted at Roza fish ladder.

[b]Spring chinook calculated to spawn in Yakima River below Roza Dam from 321 redds at 2.2 fish/redd = 706 fish.

[c]Estimate of percentage of 544 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.7% of adult run returning to the Yakima and 33.3% to Naches.

[d]Estimated that 100% of the adults in the Yakima are four year old fish.

[e]Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

[f]Estimate of percentage of 810 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.3%).

[g]Estimated that 50% of the adults in the Naches system are four year old fish.

findings at Wapatox Smolt trap indicating an extensive fall outmigration, and the preliminary findings on the Chandler Canal Entrainment study (Anonymous, 1985) indicating fish movement in January and February there may be a large outmigration of pre-smolt spring chinook in the months when the Chandler Canal Smolt trap is inoperable due to screen removal.

6.2 HATCHERY OPERATIONS

6.2.1 OUTPLANTING STUDIES

6.2.1.1 Smolt releases

To evaluate the effectiveness of rearing and releasing hybrids and acclimating fish in earthen ponds and then allowing for a volitional release as smolts, three groups of spring chinook smolts were released from Mary's pond at RM 190 on the Yakima River and a forth group was transported from Leavenworth National Fish Hatchery and scatter-planted directly into the upper Yakima River between RM 155 and 200. The release data for the 1986 acclimation pond and river-released groups of smolts is presented in Table 53.

Similar releases were made from Nile Springs pond and the upper Yakima River in 1983 and 1984 and from Mary's pond and the upper Yakima River in 1985. The 1986 release groups represent the first time the wild x wild and wild x hatchery hybrids were released. The survival of these release groups to Prosser is discussed extensively in the smolt trapping section of this report. The 1983 release groups returned as five year old adults in 1986 and the 1984 release groups returned as four year old adults. Their survival rates will be discussed in the Hatchery Adult Return section of this report.

Table 53. Rearing, marking and release data for acclimated and non-acclimated experimental spring chinook releases in 1986.

	Hatchery stock acclimated	Hatchery stock non-acclimated	Hybrid acclimated	Native acclimated
Brood stock	Carson	Carson	Carson-Yakima cross	Yakima-Yakima cross
Rearing site	Leavenworth N.F.H.	Leavenworth N.F.H.	Leavenworth N.F.H.	Leavenworth N.F.H.
Rearing facility	raceway	raceway	raceway	raceway
Release type	volitional from pond	trucked	volitional from pond	volitional from pond
Release site	Mary's pond[a]	Upper Yakima River[b]	Mary's pond[a]	Mary's pond[a]
Release date	March 28	April 18[c]	March 28	March 28
Total number released	51,846	50,657	46,476	33,052
Number branded	5,910	6,383	5,438	5,255
Percent branded	11.4	12.6	11.7	15.9
Brand code	LA3(1)	RA3(1)	LA3(4)	RA3(4)
Date branded	10-1-85	10-1-85	10-1-85	10-1-85
Number with ad-CWT	47,076	46,858	40,434	29,449
Tag code	5-15-49	5-15-48	5-15-50	5-15-51
Tag retention	90.8%	92.5%	87.0%	89.1%
Size at release	124 mm 20.6/lb	125 mm 19.9/lb	130 mm 17.2/lb	129 mm 17.1/lb

[a]Located RM 144.9, Yakima River.
[b]Ellensburg-Cle Elum area, median release point RM 118, Yakima River.
[c]Median of two releases occurring April 9 and April 28.

6.2.2 BROOD STOCK EVALUATIONS

An experimental brood stock program was undertaken in 1984 and continued in 1985 to evaluate the effectiveness of using spring chinook adults from the Yakima River as a source of gametes for hatchery reared fish in an attempt to maintain the genetic components indigenous to the Yakima Basin. Crosses were made to obtain four different release groups; wild males and wild females, wild males and hatchery females, and two groups of hatchery males and females. The first three groups will be released in acclimation ponds and the fourth group will be released directly into the Yakima River and compared with survival of group three - a continuation of the acclimation pond vs. river release study. The required crosses were made in 1985 from 97 Yakima River brood stock adults taken from the Roza adult trap. The hybrids will all be reared at Leavenworth National Fish Hatchery and released as smolts. The first releases, of the 1984 brood year products, were made from Mary's pond and the upper Yakima in 1986. The resulting progeny of the 1985 crosses will be released in 1987.

6.2.3 ADULT HATCHERY RETURNS

Spring chinook adults from eight different hatchery release groups were recovered in 1986. These fish were identified by the coded wire tags recovered in the Yakima Indian Nation Zone 6 ceremonial and subsistance fishery, the Yakima River ceremonial dipnet fishery, from spawning ground surveys and carcass recovery surveys conducted on the Yakima and Naches River systems in September and October of 1986, and from the adult trap at Roza Dam. A total of 315 fish were inspected for adipose fins and coded wire tags in the Naches River in 1986. All fish passing Roza Dam were inspected for adipose clips. Any clipped fish were sacrificed to increase the the recovery of coded wire tags. Table 54 presents the release data for all hatchery groups that could possibly return to the Yakima system as three, four, or five-year-old fish in 1986.

Table 54. Tag data on all hatchery release groups that could have returned to the Yakima system in 1986.

Brood year	Tag code	Total number released	Release site	Number tagged	Mark rate (%)
1981	5-13-38	99,725	Nile Springs	94,529	94.8
1981	5-13-39	97,725	Upper Yakima	94,198	97.1
1982	5-11-47	29,636	Nile Springs	28,450	96.0
1982	5-11-48	45,552	Upper Yakima	41,573	97.7
1983	5-15-33	45,195	Marys Pond	43,297	95.8
1983	5-15-32	42,210	Upper Yakima (April)	40,436	95.8
1983	5-15-28	102,837	Upper Yakima (June)	93,064	90.5
1983	5-15-29	102,833	Upper Yakima (Sept.)	93,064	90.5
1983	5-15-30	108,305	Upper Yakima (Nov.)	102,229	94.4

The 1986 tag recoveries were from the 1983 Nile Springs pond and upper Yakima release groups; the 1984 Nile Springs pond and upper Yakima groups; the June, September and November 1984 fry and pre-smolt release groups and the 1985 Mary's pond release group (a three year old jack). The expanded recoveries for each of the release groups is presented in table 55.

Table 55. Estimated expanded returns of hatchery released smolts.

Tag code	Source of recovery[a]	Number recovered	Sample rate[b,c]	Sample expanded	Mark rate	Total recovery
5-13-38	3	2	0.109	18	.948	19
5-13-39	4	12	1.00	12	.971	12
5-11-47	3	2	0.109	18	.96	19
5-11-48	4	12	1.00	12	.977	12
5-15-28	4	1	1.00	1	.905	1
5-15-29	4	1	1.00	1	.905	1
5-15-30	4	1	1.00	1	.944	1
5-15-33	4	1	1.00	1	.958	1

[a] Recovery code 1 = Zone 6 ceremonial and subsistence fishery; 2 = Yakima River dipnet fishery; 3 = Naches spawner and carcass surveys; 4 = Yakima River Roza fish trap.

[b] In the Naches system 315 fish were inspected from an estimated 2,891 spawners.

[c] In the Yakima River 389 fish were inspected from an estimated 2,501 spawners.

The 1986 adults returning from the 1983 Nile Springs pond and upper Yakima release groups were five-year-old fish, and complete the data necessary to calculate the smolt to adult survival rate for these two hatchery release groups. In 1986 an estimated 19 five-year-old adults returned from the Nile Springs pond release. This gave a total adult return of 78 fish when added to the 59 four-year-old fish that returned in 1985. There were 99,725 smolts released from Nile pond in 1983. This gives a smolt to adult survival rate of 0.08% for the acclimated fish. This 0.08% is based on the number of smolts released into the acclimation pond and therefore is not comparable to the wild smolt to adult survival rate of 4.4%, which is based on the number of smolts that passed Prosser Dam. It was estimated that 38,394 Nile Springs pond smolts passed Prosser Dam in 1983. The survival rate from "smolt-at-Prosser" to adult for the 1983 acclimated group is therefore 0.2%.

A similar analysis of the 1983 upper Yakima River release group indicates that 12 five-year-old adults returned in 1986 and 31 four-year-old fish returned in 1985. The total estimated adult return was thus 43 fish. There were 97,725 smolts released in the upper Yakima in 1983. This gives a "smolt-at-release" to adult survival rate of 0.04%. It was estimated that 20,131 of these smolts survived passage to Prosser Dam in 1983. The smolt-at-Prosser to adult survival rate was thus 0.21%.

Survival rates for smolt-at-Prosser to adult are almost identical between the acclimated and non-acclimated 1983 release groups. The survival rate from release site to Prosser, however, was almost twice as great for the acclimated fish (38.5%) as for the non-acclimated fish (20.6%). Thus, acclimation and volitional release apparently increased the relative fitness of acclimated smolts, perhaps by allowing recovery from the stress of handling and transportation and/or the development of adaptive behavior patterns (e.g., predator avoidance responses).

The other two release groups that had more than one fish returning in 1986 were the 1984 Nile Springs pond and the 1984 upper Yakima releases. Returns from Nile pond were estimated at 19 four-year-old adults. As 29,636 smolts were released from Nile pond in 1984, the survival rate from smolt-at-release to adult is currently 0.06%. It was estimated that 17,219 of these acclimated smolts survived to Prosser. This gives a survival rate for smolt-at-Prosser to adult of 0.11% for four-year-old adults. Both survival rates will increase if any five-year-old fish return in 1987.

A total of 12 four-year-old adults returned in 1986 from a release of 45,552 smolts in the upper Yakima in 1984. The survival rate from smolt-at-release to four-year-old adult is thus 0.03%. As 15,898 of these smolts were estimated to have survived to Prosser in 1984, the survival rate for smolt-at-Prosser to four-year-old adult is 0.08%. Again, both survival rates will increase with the return of five-year-old adults in 1987.

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Appendix A.

Daily captures of spring chinook fry

in Yakima River emergence traps

March, 1986--April, 1986

and

Weekly raw catches of spring chinook and rainbow-steelhead

at Wapatox smolt trap in 1986.

Table A.1 Daily captures of spring chinook fry in Yakima River emergence traps in March 1986.

Calendar date	Julian date	Salmon La Sac		Sun Country 1		Sun Country 3		Elk Meadows 1		Elk Meadows 2		LDS		Run Acres		Side channel	
		Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum
03-17-86	76	D.I.[a]		N.I.[b]		N.I.		N.I.		N.I.		N.I.		N.I.		N.I.	
03-18-86	77	–[c]		N.I.		N.I.		D.I.		N.I.		N.I.		N.I.		N.I.	
03-19-86	78	–		N.I.		D.I.		–		N.I.		N.I.		N.I.		N.I.	
03-20-86	79	–		N.I.		–		–		N.I.		N.I.		N.I.		N.I.	
03-21-86	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-22-86	81	–		N.I.		–		–		N.I.		N.I.		N.I.		N.I.	
03-23-86	82	–		N.I.		–		–		N.I.		N.I.		N.I.		N.I.	
03-24-86	83	–		N.I.		–		–		N.I.		N.I.		N.I.		N.I.	
03-25-86	84	0	0	N.I.		691	691	0	0	N.I.		N.I.		N.I.		N.I.	
03-26-86	85	–		N.I.		65	756	–		–		–		N.I.		D.I.	
03-27-86	86	–		D.I.		138	894	–		–		–		D.I.		–	
03-28-86	87	0	0	0	0	144	1038	0	0	0	0	0	0	0	0	0	0
03-29-86	88	0	0	0	0	45	1083	0	0	0	0	0	0	0	0	0	0
03-30-86	89	–		–		–		–		–		–		–		–	
03-31-86	90	0	0	0	0	244	1327	0	0	0	0	0	0	0	0	0	0

[a]Date installed.
[b]Net installed.
[c]Not checked.

Appendix Table A.2. Daily captures of spring chinook fry in Yakima River emergence traps in April 1986.

Calendar date	Julian date	Salmon La Sac		Sun Country 1		Sun Country 3		Elk Meadows 1		Elk Meadows 2		LDS		Run Acres		Side channel	
		Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum
04-01-86	91	0	0	0	0	0	1327	0	0	0	0	0	0	0	0	0	0
04-02-86	92	0	0	0	0	43	1370	0	0	0	0	0	0	0	0	0	0
04-03-86	93	0	0	0	0	0	1370	0	0	0	0	0	0	0	0	0	0
04-04-86	94	0	0	0	0	0	1370	0	0	0	0	0	0	0	0	46	46
04-05-86	95	0	0	0	0	37	1407	0	0	0	0	0	0	0	0	11	57
04-06-86	96	0	0	0	0	8	1415	0	0	24	24	0	0	0	0	20	77
04-07-86	97	0	0	0	0	22	1437	0	0	115	139	0	0	0	0	45	122
04-08-86	98	0	0	0	0	34	1471	61	61	158	297	0	0	0	0	43	165
04-09-86	99	0	0	0	0	21	1492	34	95	64	361	0	0	0	0	28	193
04-10-86	100	0	0	0	0	0	1492	0	95	23	384	0	0	0	0	35	228
04-11-86	101	0	0	7	7	3	1495	3	98	66	450	0	0	0	0	27	255
04-12-86	102	0	0	120	127	0	1495	7	105	21	471	0	0	0	0	6	261
04-13-86	103	0	0	197	324	0	1495	48	153	17	488	0	0	0	0	47	308
04-14-86	104	0	0	393	717	0	1495	55	208	26	514	0	0	0	0	41	349
04-15-86	105	0	0	74	791	0	1495	71	279	0	514	0	0	0	0	38	387
04-16-86	106	0	0	20	811		1495	150	429	0	514	0	0	0	0	81	468
04-17-86	107	0	0	30	841	0	1495	52	481	4	518	1	1	0	0	28	496
04-18-86	108	0	0	151	992	0	1495	80	561	3	521	0	1	0	0	11	507
04-19-86	109	0	0	90	1082	0	1495	65	626	0	521	0	1	0	0	46	553
04-20-86	110	0	0	230	1312	0	1495	50	676	0	521	0	1	0	0	11	564
04-21-86	111	0	0	613	1925	0	1495	141	817	120	641	45	46	0	0	27	591
04-22-86	112	185	185	322	2247	-	1495	90	907	84	725	45	91	0	0	58	649
04-23-86	113	304	489	159	2406	0	1495	292	1199	184	909	205	296	0	0	22	671
04-24-86	114	148	637	41	2447	-	1495	76	1275	53	962	140	436	17	17	52	723
04-25-86	115	119	756	20	2467	0	1495	25	1300	42	1004	166	602	322	339	14	737
04-26-86	116	119	875	17	2484	-	1495	32	1332	20	1024	69	671	670	1009	24	761
04-27-86	117	61	936	0	2484	0	1495	10	1342	21	1045	756	1427	364	1373	37	798
04-28-86	118	184	1120	17	2501	-	1495	28	1370	75	1120	689	2116	150	1523	64	862
04-29-86	119	189	1309	6	2507	0	1495	10	1380	67	1187	105	2221	45	1568	37	899
04-30-86	120	123	1432	5	2512	-	1495	4	1384	13	1200	43	2264	8	1576	65	964

Appendix Table A.3. Daily captures of spring chinook fry in Yakima River emergence traps in May 1986.

Calendar date	Julian date	Salmon La Sac		Sun Country 1		Sun Country 3		Elk Meadows 1		Elk Meadows 2		LDS		Run Acres		Side channel	
		Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum
05-01-86	121	227	1659	5	2517	0	1495	4	1388	10	1210	4	2268	13	1589	16	980
05-02-86	122	152	1811	3	2520	-	1495	7	1395	22	1232	4	2272	4	1593	3	983
05-03-86	123	146	1957	11	2531	0	1495	5	1400	1	1233	11	2283	1	1594	0	983
05-04-86	124	93	2050	10	2541	-	1495	5	1405	5	1238	48	2331	247	1841	0	983
05-05-86	125	76	2126	7	2548	0	1495	2	1407	15	1253	121	2452	329	2170	0	983
05-06-86	126	54	2180	3	2551	-	1495	0	1407	21	1274	68	2520	141	2311	0	983
05-07-86	127	151	2331	15	2566	0	1495	3	1410	65	1339	30	2550	138	2449	0	983
05-08-86	128	147	2478	17	2583	0	1495	11	1421	4	1343	13	2563	153	2602	-	983
05-09-86	129	64	2542	19	2602	0	1495	12	1433	11	1354	137	2700	107	2709	0	983
05-10-86	130	71	2613	14	2616	-	1495	6	1439	52	1406	20	2720	90	2799	0	983
05-11-86	131	53	2666	8	2624	0	1495	2	1441	21	1427	5	2725	21	2820	1	984
05-12-86	132	57	2723	14	2638	-	1495	7	1448	36	1463	53	2778	19	2839	0	984
05-13-86	133	120	2843	9	2647	0	1495	4	1452	8	1471	37	2815	38	2877	0	984
05-14-86	134	34	2877	11	2658	-	1495	9	1461	4	1475	10	2825	31	2908	0	984
05-15-86	135	18	2895	1	2659	0	1495	4	1465	6	1481	1	2826	34	2942	0	984
05-16-86	136	15	2910	3	2662	-	1495	2	1467	2	1483	10	2836	7	2949	1	985
05-17-86	137	51	2961	0	2662	0	1495	4	1471	4	1487	5	2841	3	2952	0	985
05-18-86	138	84	3045	2	2664	-	1495	9	1480	5	1492	12	2853	74	3026	0	985
05-19-86	139	70	3115	5	2669	0	1495	14	1494	0	1492	14	2867	2	3028	0	985
05-20-86	140	39	3154	5	2674	0	1495	5	1499	0	1492	14	2881	3	3031	0	985
05-21-86	141	12	3166	1	2675	0	1495	0	1499	1	1492	4	2885	6	3037	0	985
05-22-86[a]	142	-		-		-		-		-		-		-		-	
05-23-86	143	7	3173	3	2678	0	1495	0	1499	8	1500	2	2887	2	3039	2	987
05-25-86	145	31	3204	0	2678	0	1495	1	1500	0	1500	0	2887	24	3063	3	990
05-27-86	147	48	3252	2	2680	-	1495	0	1500	0	1500	1	2888	0	3063	0	990
05-29-86	149	18	3270	0	2680	-	1495	20	1520	2	1502	2	2890	15	3078	0	990
05-31-86	151	16	3286	2	2682	-[b]		3	1523	2	1504	3	2893	-	3078	0	990

[a]After 05/21/86 traps were checked every other day.
[b]Date trap was removed.

Appendix Table A.4. Daily captures of spring chinook fry in Yakima River emergence traps in June 1986.

Calendar date	Julian date	Salmon La Sac		Sun Country 1		Sun Country 3		Elk Meadows 1		Elk Meadows 2		LDS		Run Acres		Side channel	
		Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum	Day	Cum
06-02-86	153	12	3298	0	2682			0	1523	0	1504	0	2893	0	3078	2	992
06-04-86	155	24	3322	0	2682			0	1523	0	1504	2	2895	3	3081	0	992
06-06-86	157	10	3332	0	2682			0	1523	0	1504	1	2896	0	3081	0	992
06-09-86	160	0	3332	0	2682			0	1523	0	1504	1	2897	0	3081	0	992
06-11-86	162	15	3347	1	2683			1	1524	0	1504	1	2898	0	3081	6	998
06-13-86	165	6	3353	0	2683			0	1524	0	1504	0	2898	0	3081	1	999
06-16-86	168	3	3356	0	2683			0	1524	0	1504	1	2899	0	3081	4	1003
06-18-86	170	0	3356	0	2683			0	1524	0	1504	1	2900	0	3081	0	1003

Appendix Table A.5 Weekly raw catches for spring chinook and rainbow-steelhead at Wapatox, 1986.

Date	Chinook smolt	Chinook pre-smolts	Rainbow-steelhead smolt	Rainbow-steelhead pre-smolt
3/22-24	1	0	0	4
3/25-31	26	6	1	11
4/1-7	27	3	0	9
4/8-14[a]	12	2	2	6
4/15-21	290	2	36	40
4/22-28	254	9	131	49
4/29-5/5	114	12	72	22
5/6-12	184	31	266	31
5/13-19	91	30	246	44
5/20-26	116	85	440	55
5/27-6/2	81	16	51	8
6/3-9	29	8	5	14
6/10-16	27	6	45	5
6/17-23	21	12	19	5
6/24-30	17	9	11	0
7/1-7	0	55	0	12
7/8-14	0	31	0	19
7/15-21	0	132	0	18
7/22-28	0	27	0	12
7/29-8/4	0	67	0	18
8/5-11	0	47	0	21
8/12-18	0	100	0	46
8/19-25	0	34	0	21
8/26-9/1	0	53	0	29
9/2-8	0	124	0	30
9/9-15	0	198	0	24
9/16-22	0	218	0	46
9/23-29	0	261	0	170
Total	1,290	1,578	1,345	769

[a]Trap inoperable 2 days during the week.

Appendix B.

Prosser smolt trap efficiency tests and species passage data

Prosser smolt trap efficiency testing

Prosser Dam and Chandler Canal are located at river mile 47, well below spring chinook spawning and rearing areas on the Yakima River. Therefore, the spring chinook production of the entire system, as well as the effect of enhancement measures, can be assessed by an accurate count of outmigrants at Prosser Dam.

Chandler Canal diverts a fairly constant 1200-1400 cfs of water from the Yakima River at Prosser Dam. The water flows unobstructed for about 1.5 miles at which point a series of 10 rotary screens and a bypass pipe divert fish to a smolt trap. The efficiency with which outmigrating smolts are captured at this trap has only recently been estimated because fish must traverse a considerable length of canal before they enter the trap, and because river discharge, and therefore trapping efficiency, varies dramatically during the smolt run.

Since 1983, river discharge at Prosser Dam has ranged from 1,300 cfs to 16,000 cfs between March and July, and has been impacted by abrupt changes in run-off, reservoir releases and upstream irrigation demands. River discharge diverted into the canal varied from about 10 to 93 percent in this period. Since larger diversions entrain larger numbers of outmigrating smolts, enumerating outmigrants required the development of a relationship between trapping efficiency and river discharge. This was accomplished by making repetitive releases of branded fish over a wide range of river discharges.

Allowance must be made for a distinct intra-canal mortality rate when estimating trapping efficiency at the Chandler Canal smolt trap. Marked fish may spend a considerable period traversing the canal. Median canal residence time in 1984, 1985 and 1986 was roughly has ranged from one to three days, although some smolts took as long as 40 days in 1984 and 31 days in 1985 and 1986. Relative structural heterogenity and habitat volume are reduced in the canal, and the rotary screens may represent a unique cause of stress or physical trauma. The intra-canal mortality rate is therefore greater than that which occurs in the river because of impingement on the screens and increased vulnerability to predators.

Trap efficiency was estimated as the ratio of the number of recaptures of fish released in the river to the number of fish available for capture during the 2-7 day "base period" after release. The number of fish available for capture was estimated as the product of the number of fish released in the river, the river survival rate, and a term representing the combined effects of intra-canal mortality and stress-induced migration lag.

The aforementioned approach entailed the following basic experimental protocol in 1984. Vigorous, uninjured fish were removed from the trap and given a caudal fin clip and a distinctive freeze-brand the night before release. The brand designated whether fish were destined for release within the canal ("canal fish"), or in the river ("river fish"). River release sites were 2.5 and 3.5 miles above the canal inlet ("2-mile" and "3-mile" releases, respectively). Branded fish were held in 200-gallon plastic tanks which were continuously aerated by a 1/4 h.p. air compressor fitted with air stones. Surviving fish were released the following morning between 0800 and 0900 hrs. Intra-canal releases were made approximately 100 ft below the inlet where intake turbulence had dissipated and the possiblity of fish escaping back into the river was minimal. River-released fish were released from a boat in the middle of the river. Canal releases were made from the sides of the canal. Only vigorous, actively swimming fish were released.

The protocol followed in 1985 and 1986 was similar but had four major modifications. First, branded fish were held a minimum of 24 hours in a 10x8x4 foot flow-through holding tank. Second, intra-canal releases were made several hundred yards below the headgates, both in the morning and after dark. Third, on the day of a test release, a random sample of fish from all release groups was placed in a 27 cubic foot nylon-mesh cage and monitored for mortalities for the duration of the test. Finally, river releases were made only from the two-mile point.

The first modification represents an attempt to reduce the impact of handling stress on the migratory disposition and survival of test fish. Mean pre-release holding time was about 2 days in 1985 and 1986. Two days represents a compromise figure; it is long enough to allow some recovery from handling stress, and the culling of "weak" fish that would otherwise have died shortly after release, yet not so long as to generate confinement stress.

There were three reasons for the second modification of intra-canal releases. The first was to eliminate the possibilty of canal fish swimming upstream and out of the canal through the head-gates, the second was to assess the magnitude of predator mortality in the canal, and the third was to estimate the instantaneous rate of natural mortality in the canal.

Water velocity from the headgates to the release point is about 4-7 feet per second. The probability of a smolt swimming several hundred yards against such a current is remote. Night releases were made in an attempt to assess losses from diurnal predators (gulls and squawfish) known to frequent the canal. If one assumes that the majority of predator losses occurs immediately after release, before smolts have had a chance to locate cover, then a comparison of the survival of day and night canal releases should estimate losses attributable to diurnal predators.

Night releases also served to provide an estimate of the instantaneous rate of natural mortality, M, in the canal. Seber (1982) developed a formula to estimate M from release number and recapture rate when a number of marked fish suffer simultaneous exponential losses to natural mortality and exploitation. If most unhandled migrants enter the canal at night and leave the system, either through natural mortality or being trapped, at the same exponential rate as branded smolts released into the canal at night, it is possible to use Seber's formula to estimate M from the release number and mean recapture time of marked, night-released test fish.

The third modification was designed to assess stress-induced mortality in canal fish by holding a random sample of fish from each release group in a cage floating in the canal until the recapture of the last test fish. This method possibly overestimated stress-induced mortality. Prolonged confinement of migrating smolts is itself a stressor, as is the descaling and abrasion that resulted from daily mortality checks when the cage was partially pulled from the water. In addition, some fish were able to "gill" themselves by forcing their heads through the 3/8 inch mesh of the cage.

The fourth and final modification, making river releases only from the 2-mile point in 1985 and 1986, was instituted because river mortality was determined to be negligible in 1984.

The goal of this effort was to determine a relationship between efficiency and river discharge for spring chinook. Specifically it was hoped a statistically significant relationship between efficiency and the mean percent discharge diverted into the canal (P.D.C.) during the base period could be developed.

Efficiencies were estimated over a 2 to 7-day base period by means of the following expression:

$$E_i = \frac{C_{ri}}{R_{ri}\ (S_{ri})^x\ (C_{ci}/R_{ci})} \qquad \text{equation 1.}$$

Where E_i = estimated percent trapping efficiency for the i^{th} release;

C_{ri} = total base period recaptures of river-released fish during the i^{th} release;

R_{ri} = the number of fish released in the river during the i^{th} release;

$(S_{ri})^x$ = river survival for the i^{th} release;

(S_{ri}) = river survival per mile of river traversed in the i^{th} release;

x = miles of river traversed;

(C_{ci}/R_{ci}) = an expression representing the percent of river fish that resumed migration during base period and, if entering the canal, survived passage through it in release i;

C_{ci} = the number of recaptures of fish released in the canal during base period in release i;

R_{ci} = the number of fish released in the canal in release i.

Appendix Tables B.1, B.2 and B.3 summarize the results of releases in 1984, 1985 and 1986. Appendix Tables B.4 and B.5 and B.6 list the daily recaptures of 1984, 1985 and 1986 releases. Three points are evident from these tables. First, the combined data span a wide range of diversions into the canal (25.7 to 78.4 percent). Second, the four tests involving simultaneous releases of steelhead and chinook resulted in closely comparable efficiency estimates. Finally, Tables B.4, B.5 and

B.6 indicate that the speed of outmigration of fish released in 1985 and 1986 was greater than in 1984.

Two factors probably contributed to the accelerated movement of test fish in 1985 and 1986. In 1985 and 1986 there were functional exit ports both on the floor of the canal and near the surface, whereas only the canal-floor exits were functional in 1984. One would expect the recapture distribution of test fish in 1984 to reflect whatever reluctance smolts may have had in sounding the 12 to 14 feet necessary to reach bottom exits. In addition, 1985 releases were, on average, about two weeks later than in 1984. Smolts are known to migrate more rapidly as spring progresses and the relatively protracted recapture period for 1984 releases is not unexpected.

The P.D.C.-efficiency data from both years was fit to a logistic relationship with the aid of a non-parametric computer program (Appendix Fig. B.1). Linear, log, power and exponential regressions were run as well. Although the log regression fit the data slightly better than the logistic — residual sum of squares for log and logistic fits were 4,067 and 4,267, respectively — the logistic fit was chosen because it gave more realistic estimates with extreme P.D.C. values. In particular, the log fit predicted efficiencies below zero for P.D.C. values below 19, and efficiencies greater than 100 for P.D.C. values above 76. Efficiencies predicted by a logistic relationship are constrained to fall between 0 and 100 percent.

There are biological reasons to expect a logistic relationship between P.D.C. and efficiency. When P.D.C. is high,

Appendix Table B.1. Summary of 1984 efficiency tests at Chandler Canal (Recaptures changed to make chronology identical to 1985 and 1986).

Release number	Species	Date	Number of canal fish released	Number of river fish released	Base period length	Base period P.D.C.	Efficiency (percent)
1.	Spring chinook	4/10/84	198	358	7 days	45.5	41.5
3.	Spring chinook	4/17/84	118	270	7 days	40.1	73.3
5.	Spring chinook	4/20/84	167	530	7 days	43.8	62.2
5.	Spring chinook	4/27/84	215	598	7 days	53.9	60.3
6.	Spring chinook	4/29/84	138	197	7 days	53.2	62.7
10.	Spring chinook	5/11/84	79	105	3 days	54.6	94.0
10.	Steelhead	5/11/84	70	120	3 days	54.6	91.1
11.	Spring chinook	5/15/84	100	95	3 days	29.3	21.0
11.	Steelhead	5/15/84	70	99	1 day	29.0	27.2
12.	Spring chinook	5/22/84	31	89	3 days	27.2	11.6

Releases 2, 8, and 9 were exclusively intra-canal, while data from release 7 was discarded due to errors in brand reading.

Appendix Table B.2. Summary of 1985 efficiency test at Chandler Canal.

Test number	Species	Date	Pre-release holding time (days)	Number canal day	released canal night	River	Base period (days)	Mean P.D.C.	Efficiency (percent)
1.	Spring chinook	4/20/85	1-3	55	—	193	3	35.4	33.0
2.	Spring & fall chinook	5/2/85	1-2	87	—	204	2	67.4	87.0
2.	Steelhead	5/2/85	1-2	157	—	237	2	67.4	90.3
3.	Spring & fall chinook	5/9/85	1-2	197	—	224	2	78.4	109.6
3.	Steelhead	5/9/85	1-2	201	—	225	2	78.4	102.2
4.	Spring & fall chinook	5/12/85	1-2	126	106	235	6	67.4	95.2
5.	Spring & fall chinook	5/20/85	3	194	199	232	5	39.7	58.7
6.	Spring & fall chinook	5/24/85	1	158	114	300	4	37.4	66.2
7.	Spring & fall chinook	5/26/85	1-2	116	—	178	3	40.5	66.5
8.	Spring & fall chinook	5/31/85	2	103	92	198	7	59.1	99.2
9.	Spring & fall chinook and coho	6/8/85	4	74	—	258	4	25.7	20.5

spill over the dam is minimal. In addition, the thalweg of the river is shifted into the canal. If migrating smolts avoid shallow areas, and if their movements are affected by the thalweg, one would expect large numbers of migrants to enter the canal when P.D.C. is high.

Appendix Table B.3. Summary of the 1986 efficiency tests at Chandler Canal.

Test number	Species	Release date	Pre-released holding time (days)	Number released day canal	Number released night canal	Number released river	Base period (days)	Mean P.D.C.	Efficiency (percent)
1	Spring chinook	4-12-86	2-4	109	230	207	3	36.2	62.5
2	Spring chinook	4-15-86	2-3	96	118	321	5	54.6	67.0
3	Spring chinook	4-18-86	1-2	109	108	193	6	60.7	74.5
4	Spring chinook	4-30-86	2	101	101	218	6	72.8	74.5
5	Spring chinook	5-7-86	1-2	91	87	205	6	57.1	94.6
6	Spring chinook	5-10-86	2	75	75	208	3	62.7	79.1
7	Spring chinook	5-19-87	3	91	93	123	5	62.1	86.7
8	Spring chinook	5-22-86	1-2	94	95	135	5	66.6	93.6
9	Spring chinook	5-26-86	3-4	67	75	124	2	53.2	77.8

Appendix Table B.4 Recaptures of branded chinook in 1984 efficiency tests at Chandler Canal. (To make data compatible with efficiency tests in 1985 and 1986, capture days have been redefined as a 24 hour period beginning and ending at 0800.)

Recapture day	Canal recaptures										Total	2-mile recaptures								Total	3-mile recaputres			
	Release dates											Release dates									Release date			
	04/10/84	04/12/84	04/17/84	04/10/84	04/27/84	04/29/84	04/30/84	05/11/84	05/15/84	05/22/84	TOTAL	04/10/84	04/19/84	04/20/84	04/27/84	04/29/84	05/11/84	05/15/84	05/22/84	TOTAL	04/10/84	04/20/84	04/27/84	TOTAL
1	55	15	14	49	62	23	40	17	17	5	297	11	17	31	32	19	20	3	1	134	9	38	20	76
2	2	4	1	8	14	2	2	3	6	1	43	4	3	8	21	3	2	0	0	41	2	17	27	46
3	2	21	6	8	14	1	4	4	7	0	67	6	11	6	12	3	8	3	1	50	5	10	18	33
4	0	2	5	1	3	0	3	1	1	1	17	2	7	6	2	1	6			24	0	5	7	12
5	0	2	1	5	3	2	5	8	1	1	28	1	4	2	4	1	2			14	1	10	3	14
6	1	1	1	1	7	1	5	1	3	0	21	1	6	1	6	2	1			17	1	8	6	15
7	0	3	3	10	2	9	9	2	4	0	42	1	4	7	4	5	4			25	1	14	5	20
8	0	1	5	2	1	1	3	0	4	0	17	1	1	5	3	4	2			16	1	11	1	13
9	0	4	1	8	2	1	4	0	0	0	20	0	6	0	5	4	0			15	0	7	4	11
10	1	5	1	2	2	0	1	0	0	0	12	1	3	2	0	1	1			8	1	4	7	12
11		2	0	3	1	1	3	0	1	1	12		2	0	2	6	0			10		4	2	6
12		4	1	2	1	0	4	2	0		14		1	0	0	0	0			1		1	3	4
13		0	0	2	0	0	1	3	0		6		1	0	4	0	1			6		5	3	8
14		1	2	1	1	0	1	0	1		7		1	0	0	1	2			4		0	0	0
15		0	0	0	0	3	1	0	0		4		1	1	3	0				5		2	1	3
16		0	0	0	1	0	0	0	1		2		0	2	2	2				6		1	1	2
17		0	0	0	0	1	0	0			1		1	1	0	1				3		1	0	1
18		0	0	0	3	0	1	0			4		0	1	0	0				1		0	2	2
19		0	0	0	1	0	0	0			1		0	0	1	2				3		0	0	0
20		1	2	0	1	0	1	0			5		1	1	0	0				2		1	1	2
21		0	2	0	0	0		3			4		0	0	1	0				1		1	0	1
22		0	0	1	1	0					2		0	0	1	2				3		1	2	3
23		0	0	0	0	0					0		0	0	0	1				1		1	0	1
24		1	0		1	1					3		1	1	0					2		0	2	2
25		0	0		0						0		1	0	0					1		0	1	1
26		0	0		1						1		0	0	1					1		0		0
27		0	0		0						0		0	0						0		0		0
28		0	0		0						0		0	0						0		0		0
29		0	0		0						0		0	0						0		2		2
30		0	0		1						1		1	0						1		0		0
31		1	0								1		0	1						1		0		0
32			0								0		0							0		0		0
33			0								0		0							0		0		0
34			0								0		1							1		1		1
35			0								0									0		0		0
36			0								0									0		0		0
37			0								0									0				0
38			0								0									0				0
39			1								1									0				0

Appendix Table B.5 Recaptures of branded chinook in 1985 efficiency test at Chandler Canal.

Recapture day	Day canal recaptures										Total
	Release dates										
	04/19/85	05/01/85	05/08/85	05/11/85	05/16/85	05/19/85	05/23/85	05/25/85	05/30/85	06/03/85	TOTAL
1	20	46	111	83	53	109	71	37	63	24	617
2	4	4	15	1	3	3	3	9	0	2	44
3	1	1	4	0	4	1	2	3	1	0	17
4	1	7	1	0	3	2	2	1	0	2	19
5	0	0	1	0	0	0	0		0		1
6	0	0	0	1	0	0	0		0		1
7	0	4	0		3	0	1		0		8
8	0		0			0			0		0
9	1		0			0			0		1
10			0			0			2		2
11			1			0					1
12						0					0
13						0					0
14						0					0
15						0					0
16						0					0
17						0					0
18						0					0
19						0					0
20						0					0
21						1					1

Recapture day	2-Mile recaptures										Total
	Release dates										
	04/19/85	05/01/85	05/08/85	05/11/85	05/16/85	05/19/85	05/23/85	05/25/85	05/30/85	06/03/85	TOTAL
1	18	75	46	121	120	81	90	39	119	8	767
2	6	27	61	22	10	6	1	8	0	0	141
3	5	14	9	5	3	0	3	3	3	0	45
4	14	6	4	1	1	2	4	0	0	2	34
5	14	10	1	1	0	1		0	0		27
6	17	10	1	1	1			0	0		30
7	3	3			2			0	0		8
8	18	1			0			0	0		19
9	7	4			0			0	1		12
10	4	1			0			0	0		5
11	2	0			0			0	0		2
12	1	0			1			1	1		3
13	2	2									4
14	4										4
15	2										2
16	0										0
17	2										2
18	0										0
19	0										0
20	1										1
21	0										0
22	0										0
23	0										0
24	0										0
25	0										0
26	0										0
27	0										0
28	0										0
29	0										0
30	0										0
31	1										1

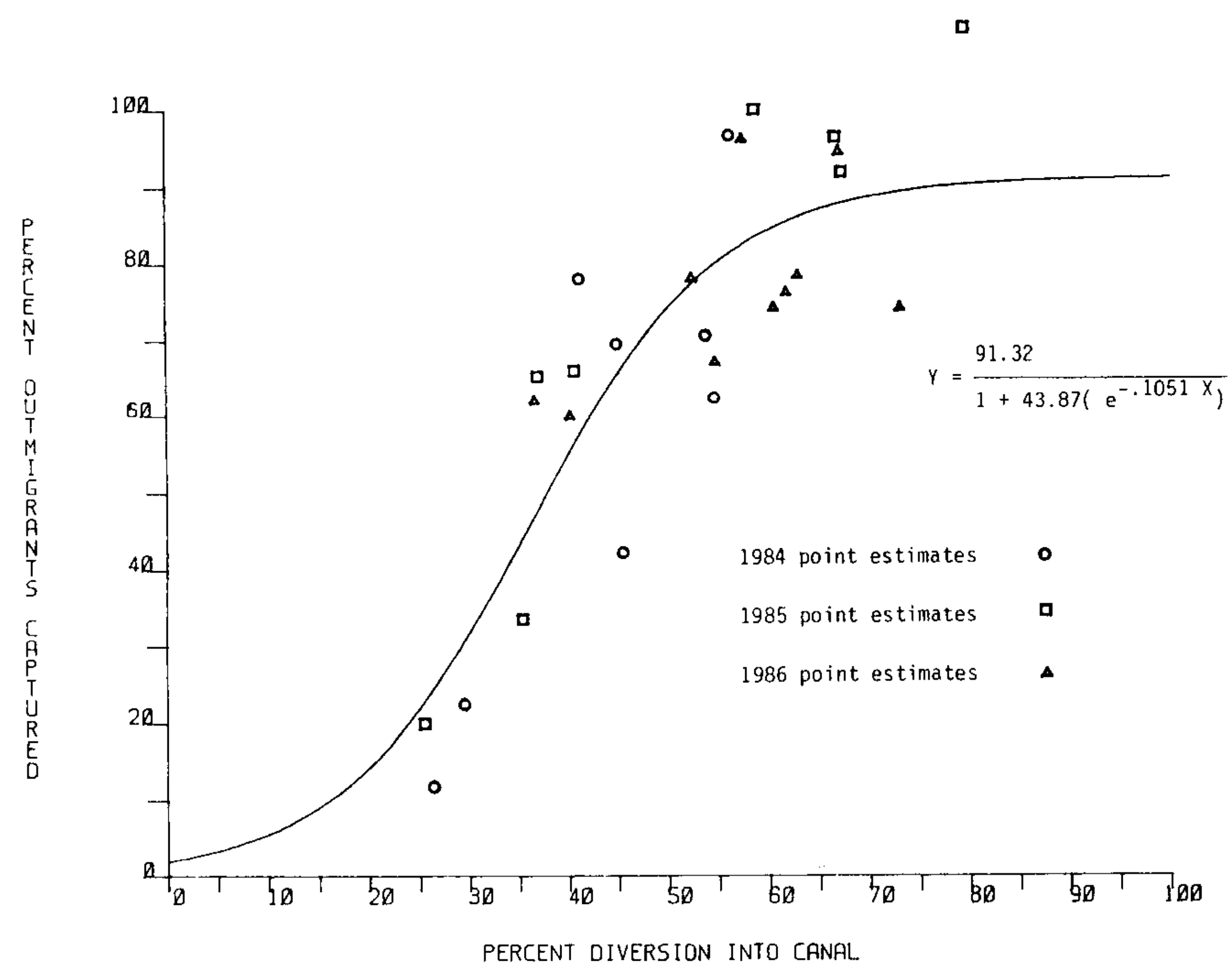
Recapture day	3-Mile recaptures					
	Release dates					
	05/11/85	05/16/85	05/19/85	05/23/85	05/25/85	TOTAL
1	99	105	157	86	46	493
2	0	7	4	1	3	15
3	0	0	1	0	1	2
4	0	1	3	0	0	5
5	0	0			1	1
6	0	1				1
7	1					1
8	0					0
9	0					0
10	0					0
11	0					0
12	1					1

Appendix Table B.6. Recaptures of branded chinook in 1986 efficiency tests of Chandler Canal.

Day of recapture	Day canal recaptures Release dates										
	04/12/86	04/15/86	04/18/86	04/30/86	05/03/86	05/07/86	05/10/86	05/19/86	05/22/86	05/26/86	TOTAL
1	58	52	57	61	25	40	21	22	17	22	375
2	19	15	9	10	25	10	4	2	3	3	100
3	3	3	2	2	2	1	2	7	4	1	27
4	5	0	0	0	1	0	3	2	2	1	14
5	2	1	0	6	6	2	1	2	3	1	24
6	2	1	1	0	1	0	3	0	2	2	12
7	1	0	4	1	0	0	2	0	2	0	10
8	0	0	1	6	2	0	0	1	1	0	11
9	0	0	1	0	2	0	0	1	0	0	4
10	0	0	2	0	1	0	0	1	3	1	8
11	0	0	1	2		0	0	0	4		7
12	0	0	1	0		0	2	1	1		5
13	2	1		1		0	2	3	1		10
14		0		0		0	0				0
15		1		0		0	0				1
16		0		0		0	0				0
17		0		0		0	1				1
18		0		0		0	2				2
19		0		2		0	0				2
20		0				1	0				1
21		0				0	0				0
22		0				2	1				3
23		0					1				1
24		1									1
25		0									0
26		0									0
27		0									0
28		0									0
29		1									1
30											
31											

Day of recapture	2-mile river recaptures Release dates									
	04/12/86	04/15/86	04/18/86	04/30/86	05/07/86	05/10/86	05/19/86	05/22/86	05/26/86	TOTAL
1	68	86	35	81	89	50	19	15	18	461
2	22	44	25	22	16	16	5	14	18	182
3	5	16	7	12	6	4	8	5	5	68
4	7	5	5	3	1	3	7	3	8	42
5	3	8	3	7	1	3	2	2	4	33
6	7	2	16	2	0	2	6	2	3	40
7	1	6	19	1	4	1	0	3	4	39
8	1	3	5	11	0	1	2	3	1	27
9	0	6	6	1	0	1	1	1	2	18
10	3	22	3	1	2	0	1	1	0	33
11	0	5	0	1	0	0	1	0	0	7
12	1	5	1	0	0	0	3	0	0	10
13	2	5	0	0	0	2	1	1	1	12
14	1	0	1	1	0	0	3	1		7
15	0	1	0	0	0	2	0	0		3
16	0	0	0	0	1	0	1	1		3
17	0	0	0	0	0	1				1
18	1	0	0	0	0	0				1
19	1	0	0	0	1	0				2
20		1	0	1	0	0				2
21		0	2	0	0	1				3
22		0		0	0	1				1
23		0		1	0	1				2
24		0		1	0					1
25		0		0	1					1
26		0		0						0
27		0		0						0
28		0		0						0
29		1		0						1
30		0								0
31		1								1

Day of recapture	Night canal recaptures										
	04/12/86	04/15/86	04/18/86	04/30/86	05/03/86	05/07/86	05/10/86	05/19/86	05/22/86	05/26/86	TOTAL
1	177	92	59	85	52	41	28	36	26	21	617
2	14	5	2	2	10	2	2	4	9	11	61
3	4	3	2	1	0	1	4	4	4	0	23
4	4	0	0	0	1		2	6	0	2	15
5	0	0	3	0	2		0	0	3	3	11
6	1	0	6	0	1		0	3	3	3	17
7	0	0	3	0	0		0	0	1	2	6
8	0	1	1	3	0		0	0	2	0	7
9	0	3	0		1		0	1	4	0	9
10	0	0	0				2	2	2	0	6
11	0	0	2				0	0	2	0	4
12	0	0	0				1	0	1	0	2
13	0	0	0				0	1		0	1
14	0	0	0				1	2		0	3
15	1	0	0				0	0		0	1
16	0	0	0				0	1		0	1
17	0	0	0				0			0	0
18	1	0	0				0			1	2
19		1	0				0				1
20			0				0				0
21			1				1				2
22			0				0				0
23			0				0				0
24			1				0				1
25							0				0
26							1				1
27											
28											
29											
30											
31											



Appendix Figure B.1. Logistic regression of efficiency on percent discharge diverted into canal.

Estimation of outmigration

Daily outmigration was estimated by dividing actual smolt trap captures by the daily trapping efficiency. A moving average efficiency was not assigned to the captures of a given day because 75.7 percent of marked, night-released canal fish in 1985 and 1986 were caught the first night. If handling stress retards migration rate, one would expect a somewhat greater proportion of unhandled fish to move through the canal and into the trap the night they entered the canal. The 7-day moving average used in 1984 and the 3-day moving average used in 1985 are now thought to be inappropriate.

Assigning bounds to outmigration estimates

The computer program with which 1984 and 1985 data was fit to a logistic relationship did not have the capacity to estimate confidence intervals. In 1987, every effort will be made to develop a mathematical technique to estimate confidence intervals around a logistic fit. At that time outmigration estimates from 1983 on will be revised and confidence intervals will be described.

Canal survival

Smolt survival in the canal may be expressed in two ways: as the cumulative proportion of fish that ultimately exit the canal, or as the proportion surviving continuous residence over a given time interval. Both measures of survival are significant. The proportion of a group of smolts that ultimately emerge from the canal alive is an obvious measure of the canal's function as a fish passage device. The intra-canal mortality rate associated with various periods of continuous residence, on the other hand, has important implications for the estimation of total smolt outmigration.

Intra-canal mortalities must be accounted for when estimating both the discharge-specific entrainment into the canal (the "efficiency" of the trap), and the total number of migrants associated with a given raw catch. The efficiency estimator (see equation 1) contains a term that corrects the number of fish available for catch for, among other things, the percent lost to intra-canal mortality. A satisfactory correction for outmigration estimates has, however, not yet been possible.

The efficiencies calculated for Chandler Canal represent the proportion of passing migrants diverted into the mouth of the canal. If no losses occurred in the canal, outmigration (N) could easily be estimated as the ratio of raw catch (C) to efficiency (E):

$$C/E = N \qquad \text{equation 2.}$$

As fish are, however, lost in the canal, the figure for raw catch must be expanded. If the instantaneous rate of natural mortality in the canal, M, were known, and if unbranded smolts passed through the canal in one day, this expansion could be made by dividing the raw catch by the one-day canal survival rate:

$$\frac{C/e^{-M}}{E} = N \qquad \text{equation 3.}$$

The correction summarized in equation 3 was made to outmigration estimates from 1983 through 1986. Seber's (1982) formula was used to estimate M from release number and recapture rate of marked smolts released into the canal at night. The correction entailed four assumptions:

1.) That unhandled smolts enter the canal at night;
2.) That unhandled smolts move through the canal in one 24-hr day;
3.) That mortalities are the same for marked and unmarked smolts; and
4.) That the rates of "leaving the system," either through natural mortality or being recaptured, are both exponential.

The first two assumptions are reasonable. Wasserman and Hubble (1983) observed that the majority of the spring chinook captured at the Chandler Canal trap were captured at night. As previously mentioned, 75 percent of marked fish released in the canal at night in 1986 were recaptured the following morning. The third assumption is probably reasonable, as 48-hr mortalities among penned branded smolts was only 3.3 percent. If losses among marked fish are greater than among unmarked fish the difference would have to be attributable to predation on disoriented fish immediately following release, not to acute handling mortality. The third assumption is, however, definitely not met. Chi-square tests of virtually all canal releases are not distributed exponentially: too many fish are captured the first day, and too few there after.

Bearing in mind the qualifications on one-day survival as given estimated instantaneous rates of natural mortality, Tables B.7 and B.8 indicate that intra-canal survival is greater for fish released at night and for fish released earlier in the season. If the estimates of M are essentially correct, and if unhandled smolts move through the canal in one night, losses associated with canal passage are about 8 percent in April and 13 percent in May. If, however, the transit time of unbranded migrants is such that intra-canal losses are more accurately reflected by cumulative percent recaptures, then canal mortalities will be on the order of 15 percent in April and 28 percent in May.

Table B.7. Estimated survival rates associated with passage of Chandler Canal by branded chinook smolts released into the canal at night or in the day-time in April and May. Survival is cumulative percent recaptures or where M is the estimated instantaneous rate of natural mortality.

Month	Day-releases Survival as cumulative percent recaptures	Survival as e^{-M}	Night-releases Survival as cumulative percent recaptures	Survival as e^{-M}
April	61.0	89.3	85.2	92.0
May	57.1	81.6	72.1	87.2

Appendix Table B.8. Survival statistics for branded chinook smolts confined to a net pen in Chandler Canal and released into the canal during the day-time or after dark, 1983-1986.

Date of release	Day-time release: cumulative percent recaptured and released	Day-time release: estimated instantaneous rate of natural mortality	Day-time release: one-day survival due to natural mortality (percent)	Night-time Release: cumulative percent recaptured and released	Night-time Release: estimated instantaneous rate of natural mortality	Night-time Release: one-day survival due to natural mortality (percent)	net pen survival (percent)
7-14-86	—	—	—	51.2	-.466	62.8	—
7-8-86	—	—	—	55.2	-.430	65.0	—
5-26-86	46.3	-.277	75.7	57.3	-.154	85.7	51.7[a]
5-22-86	45.7	-.119	88.8	60.0	-.111	89.5	97.5
5-19-86	46.2	-.154	85.7	64.5	-.114	89.2	91.7
5-15-86	55.7	-.114	89.2	—	—	—	96.7
5-11-86	60.0	-.076	92.7	56.0	-.124	88.3	100.0
5-7-86	60.4	-.154	85.7	—	—	—	98.3
5-3-86	53.3	-.182	83.4	75.3	-.162	85.1	96.7
4-30-86	90.1	-.036	96.5	90.1	-.077	92.6	100.0
4-23-86	52.2	-.137	87.2	—[b]	—[b]	—[b]	91.7
4-18-86	72.5	-.123	88.4	74.1	-.095	90.9	88.3
4-15-86	79.2	-.086	91.8	89.0	-.069	93.3	96.7
4-12-86	84.4	-.079	92.4	87.8	-.090	91.4	96.6
6-8-85	18.9	—	—	—	—	—	—
5-31-85	64.1	-.272	76.2	55.4[c]	-.371[c]	69.0[d]	98.0
5-26-85	43.1	-.409	66.4	—	—	—	97.1
5-24-85	50.0	-.397	67.2	77.2	-.216	80.6	96.0
5-20-85	66.7	-.261	77.0	82.9	-.156	85.6	100.0
5-16-85	58.9	-.257	77.3	80.3	-.173	84.1	100.0
5-12-85	67.5	-.300	74.1	95.3	-.040	96.1	100.0
5-9-85	67.5	-.248	78.0	—	—	—	90.0
5-2-85	71.3	-.155	85.6	—	—	—	100.0
4-20-85	49.1	-.301	74.0	—	—	—	97.9
5-31-84	17.3	—[c]	—[c]	—	—	—	—
5-22-84	29.0	-.266	76.6	—	—	—	—
5-15-84	46.0	-.136	87.3	—	—	—	—
5-11-84	51.9	-.119	88.8	—	—	—	—
5-5-84	40.7	-.124	88.3	—	—	—	—
4-30-84	—	—	—	—[b]	—[b]	—[b]	—
4-29-84	33.3	-.135	87.4	—	—	—	—
4-27-84	57.2	-.102	90.3	—	—	—	—
4-20-84	61.7	-.093	91.1	—	—	—	—
4-17-84	38.1	-.095	90.9	—	—	—	—
4-15-84	53.5	-.082	92.1	—	—	—	—
4-10-84	30.8[d]	-.512[d]	59.9[d]	—	—	—	—

Mean cumulative percent recapture, day releases with simultaneous night releases = 63.2 percent.
Mean cumulative percent recapture, night releases with simultaneous day releases = 76.1 percent.
Grand mean 48-hour survival of penned fish = 96.7 percent. Mean one-day survival due to natural mortality, May night-time releases = 87.2 percent; May day-time releases = 81.6 percent.
Mean one-day survival due to natural mortality, April night-time releases = 92.0 percent; April releases = 89.3 percent.

[a] Calculated over 72 hours. Value excluded from mean.
[b] Brand confusion makes data of debious quality. Values excluded from means.
[c] Fish ere over-anesthetized during branding. These values excluded from means.
[d] Fish had to be re-branded and were inordinately stressed. These values excluded from means.

Appendix Table B.9 Legend for daily passage headings used in Appendix Tables 10 - 15.

WSCHK = Wild spring chinook

WFCHK = Wild fall chinook

HSCHK = Hatchery spring chinook, all releases.

HFCHK = Hatchery fall chinook, branded fish only.

WSTH = Wild steelhead

HSTH = Hatchery steelhead

COHO = Hatchery coho

NOV85 = Hatchery spring chinook released November, 1984, in upper Yakima. Branded fish only.

SEP85 = Hatchery spring chinook released September, 1984, in upper Yakima. Branded fish only.

HRTV = Hatchery spring chinook smolts trucked to upper Yakima in April and released immediately. Branded fish only.

POND = Hatchery spring chinook smolts allowed acclimation in pond on Yakima River before volitional release March 28. Branded fish only.

JUN85 = Hatchery spring chinook fingerlings released June, 1985, in upper Yakima. Branded fish only.

TROUT = Hatchery rainbow trout, no ad-clip, crumpled dorsal.

SELAH = Wild Yakima River spring chinook branded and released near Selah in the spring of 1985.

NACH = Wild Naches River spring chinook branded in the fall of 1985 as they migrated past Wapatox trap.

WILD = Hatchery-reared native Yakima River spring chinook smolts. Acclimated in pond on Yakima River, allowed volitional release March 28.

HYBRID = Hatchery-reared progeny of wild Yakima River males and L.N.F.H. females. Acclimated in pond on Yakima River, allowed volitional release March 28.

Appendix Table B.10. Outmigration for February, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	16	2	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	356	1	0	0	20	0	0	0	663	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
25	143	0	0	0	0	0	0	0	443	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	160	0	0	0	40	0	0	0	420	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	154	3	0	0	0	0	0	0	1385	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	171	0	0	0	24	2	0	0	1146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT	1000	6	0	0	84	2	0	0	4069	12	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0

Appendix Table B.11. Outmigration for March, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	106	2	0	0	43	2	0	0	1915	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	192	3	0	0	38	4	0	0	2692	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	942	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	111	0	0	0	0	0	0	0	2333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	103	0	0	0	0	0	0	0	1224	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	48	0	0	0	0	0	0	0	774	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	77	0	0	0	15	0	0	0	1138	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	82	0	0	0	0	0	0	0	1098	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	226	0	0	0	0	0	0	0	1887	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	122	0	0	0	0	0	0	0	1204	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	36	0	0	0	18	2	0	0	836	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	100	0	0	0	0	0	0	0	917	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	14	0	0	0	0	0	0	0	420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	322	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	12	0	0	0	12	2	0	0	286	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	42	0	0	0	0	0	0	0	240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	64	0	0	0	0	0	0	0	174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	29	0	0	0	0	0	0	0	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	27	0	0	0	0	0	0	0	242	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	30	1	0	0	0	0	0	0	200	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	144	2	0	0	34	12	0	0	368	1	0	0	0	0	6	2	0	6	17	0	0	0	0	0	0
22	67	0	0	0	6	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	56	2	0	0	6	0	0	0	186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	12	0	0	0	0	0	0	0	143	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	29	0	0	0	0	0	0	0	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	23	1	0	0	9	0	0	0	228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	59	0	0	0	9	0	0	0	384	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
28	150	2	0	0	28	12	0	0	435	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	348	15	0	0	43	16	0	0	766	58	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
30	491	14	0	0	126	38	0	0	755	3	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
31	212	3	0	0	130	18	0	0	610	2	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
TOT	3012	45	0	0	517	106	0	0	23268	94	0	0	12	0	6	2	5	6	23	0	0	0	0	0	0

Appendix Table B.12. Outmigration for April, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	102	1	0	0	163	20	0	0	605	3	0	0	0	0	0	0	0	0	7	0	0	0	7	7	7
2	131	1	0	0	89	12	0	0	452	1	0	0	0	0	6	0	0	0	0	0	0	0	12	0	0
3	117	1	0	0	76	16	0	0	558	2	0	0	25	0	25	0	5	0	10	0	0	0	0	0	0
4	264	3	0	0	165	10	0	0	684	6	0	0	17	0	17	0	0	0	4	0	4	0	4	4	0
5	483	3	0	0	352	20	0	0	896	4	0	0	0	0	9	0	0	0	4	0	4	0	13	17	0
6	1000	12	0	0	462	22	0	0	1446	5	0	0	87	0	60	0	0	0	33	0	5	5	0	11	16
7	2148	18	5	0	1055	22	0	0	2098	9	16	0	33	0	82	0	0	0	5	0	5	0	33	5	11
8	8265	49	6	0	3735	29	0	0	3011	14	28	0	50	0	28	1	0	11	94	0	11	0	44	61	61
9	12698	184	9	0	3570	40	0	0	4583	19	60	0	85	0	98	2	0	0	43	4	9	0	38	51	38
10	5979	242	6	0	2076	106	0	0	2397	14	53	0	6	0	24	0	0	12	44	3	15	3	21	29	38
11	2521	79	3	0	1324	56	0	0	1825	3	20	0	3	0	43	0	3	0	40	0	3	0	29	23	20
12	1443	18	0	0	775	55	0	0	1194	1	60	0	41	0	44	0	0	0	39	0	3	0	8	28	16
13	1756	1	2	0	833	20	0	0	1320	0	53	0	42	0	31	0	0	0	20	0	4	0	2	9	20
14	915	4	0	0	422	24	0	0	725	0	31	0	36	0	16	0	0	0	9	2	5	0	11	13	5
15	1043	52	0	0	461	31	0	0	703	0	33	0	20	0	20	0	0	0	4	0	0	1	16	22	9
16	1999	125	0	0	762	90	0	0	721	2	25	0	14	0	35	1	0	1	9	0	4	0	17	18	13
17	1939	25	0	0	708	53	0	0	599	2	9	0	7	0	27	0	1	1	11	4	2	0	9	25	14
18	792	17	0	0	371	53	0	0	371	0	11	0	16	0	32	0	0	0	2	0	0	0	6	11	9
19	607	9	0	0	369	60	0	0	529	1	25	1	6	0	47	0	1	1	8	0	0	0	2	5	7
20	867	55	0	0	535	54	0	0	641	8	13	0	10	0	121	0	0	0	12	0	1	1	8	5	5
21	1431	32	0	0	888	42	0	0	769	5	23	0	15	0	250	0	1	2	21	0	3	0	12	17	22
22	4170	45	23	0	1490	16	0	0	890	2	32	0	19	0	7	0	0	1	16	1	1	5	19	3	5
23	13177	244	72	1	5572	141	0	0	1960	8	46	0	15	0	960	0	3	9	80	0	15	13	87	82	95
24	13647	150	74	1	7063	99	0	0	3718	9	189	0	60	0	1009	1	1	7	101	1	16	24	135	63	119
25	6164	37	34	0	2438	57	0	0	1468	3	98	0	23	0	348	0	0	7	62	2	11	13	47	38	67
26	2086	13	11	0	959	2	0	0	892	0	123	0	11	0	97	0	0	0	5	0	3	5	8	14	6
27	2583	20	15	0	1023	6	0	0	1057	1	134	0	17	0	92	0	0	0	13	1	9	8	16	15	12
28	2859	29	16	0	1024	60	0	0	511	1	117	0	3	0	138	0	0	0	18	0	3	8	24	28	17
29	4184	104	22	1	1855	67	0	0	1145	2	132	0	15	0	297	0	0	3	23	1	11	15	37	34	50
30	2062	48	11	0	1251	56	0	0	807	0	136	0	3	0	291	1	0	0	16	0	3	11	37	18	31
TOT	97432	1621	309	3	41866	1339	0	0	38575	125	1467	1	679	0	4254	6	15	55	753	19	150	112	702	656	713

Appendix Table B.13. Outmigration for May, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	1622	19	42	0	1102	53	0	0	777	3	117	0	8	0	326	1	0	0	16	2	0	10	28	24	39
2	3566	26	91	1	1590	62	1	0	1138	4	132	0	24	0	713	3	0	4	16	0	3	9	34	28	21
3	2607	21	67	1	731	6	0	0	293	0	47	0	2	0	331	0	0	0	2	0	3	2	12	7	2
4	4036	87	103	2	1409	67	0	0	1773	4	261	1	32	0	529	0	5	2	14	0	3	11	25	38	15
5	1433	27	37	1	525	2	0	0	1077	4	128	0	11	0	403	0	0	0	7	0	3	0	10	13	6
6	2386	15	61	0	776	2	0	0	680	3	189	2	8	0	607	0	0	0	7	2	5	7	14	4	7
7	5128	63	131	2	1244	52	0	0	2855	9	425	0	21	0	807	0	0	0	17	0	4	12	12	15	19
8	3008	163	240	13	1138	74	0	0	1342	18	441	2	3	1	921	3	0	0	8	0	3	5	17	14	18
9	2005	272	160	22	787	65	0	0	1353	6	609	2	11	0	739	4	0	0	5	1	4	13	11	10	10
10	2132	318	171	25	877	56	0	0	746	4	680	4	22	0	732	1	0	0	4	0	0	9	2	2	7
11	1759	44	141	4	937	3	0	0	1311	3	898	0	16	0	790	0	0	0	1	0	1	8	6	11	6
12	1221	7	98	1	605	50	0	0	744	4	184	0	9	0	660	1	0	0	1	0	1	12	6	4	12
13	1409	65	113	5	848	77	0	0	728	3	702	0	48	0	559	4	0	3	8	0	1	19	17	16	13
14	1025	10	82	1	729	52	0	0	784	3	639	1	102	0	588	0	0	1	3	1	1	21	9	14	13
15	491	40	238	19	506	43	0	0	732	3	450	0	90	0	475	0	0	0	1	0	1	16	6	8	5
16	454	3	220	2	358	52	0	0	511	3	357	2	85	0	330	0	0	1	7	0	0	15	1	7	7
17	665	4	322	2	226	1	0	0	556	1	276	2	21	0	251	0	0	0	0	0	0	4	4	2	2
18	563	1	272	0	190	0	0	0	657	4	241	1	43	0	210	0	0	1	0	0	0	3	1	3	0
19	658	9	318	4	108	38	0	0	983	5	266	2	85	0	277	0	0	0	1	0	0	1	3	3	3
20	573	5	277	3	188	44	0	0	741	1	313	0	40	0	257	0	0	0	0	0	0	1	2	4	0
21	961	12	465	6	499	57	0	0	1756	5	547	3	111	0	1036	1	0	0	0	0	0	11	4	8	8
22	724	75	595	62	628	52	0	0	1153	3	561	1	45	0	1484	3	0	0	2	1	0	19	7	18	2
23	756	13	621	10	703	66	0	0	549	2	470	3	27	0	759	0	0	0	2	0	0	18	7	11	3
24	682	9	560	8	628	0	0	0	607	0	418	1	40	0	669	0	0	0	0	0	0	4	2	2	0
25	1221	12	1003	9	431	3	0	0	580	2	292	1	13	0	492	0	0	0	1	0	0	4	1	2	1
26	2261	32	1857	27	683	64	0	0	1048	12	512	5	42	0	734	6	0	0	1	0	0	11	5	2	1
27	2843	364	2335	299	1215	211	0	0	1344	11	658	2	135	0	1954	7	0	1	1	0	0	31	12	7	3
28	3543	117	2911	97	1342	27	7	0	1769	7	946	2	173	0	6688	10	0	0	2	0	0	34	9	16	7
29	3737	64	3070	53	1665	69	30	0	3108	15	1871	7	238	0	7755	29	0	0	2	0	0	38	4	8	0
30	2478	51	2036	42	917	67	40	0	1275	4	1187	1	76	0	2623	6	0	2	2	0	2	25	2	5	2
31	4375	46	3594	38	1097	69	165	2	1726	5	1778	3	61	1	1757	17	0	0	0	0	0	7	5	26	12
TOT	60322	1996	22231	757	24682	1484	243	2	34696	151	16595	48	1642	2	36456	96	5	15	131	7	35	380	278	332	244

Appendix Table B.14. Outmigration for June, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	2494	178	1661	118	422	78	314	16	664	51	442	8	14	0	689	30	0	0	0	0	0	11	3	0	0
2	1066	25	710	16	166	3	720	3	348	0	190	1	5	0	290	0	0	0	0	0	0	3	0	3	0
3	796	31	929	20	286	10	751	0	380	1	369	0	12	0	278	0	0	0	0	0	0	0	2	0	0
4	388	19	258	12	45	22	801	0	402	5	157	0	3	0	365	2	0	0	0	0	0	1	0	0	0
5	287	10	191	6	26	8	1735	19	200	5	81	0	1	0	205	2	0	0	0	0	0	0	0	0	1
6	238	54	158	36	23	1	1099	33	214	1	87	2	16	0	238	2	0	0	0	0	0	0	0	0	0
7	287	4	190	3	17	0	1339	9	333	2	84	1	0	0	145	1	0	0	0	0	0	1	1	1	1
8	288	17	346	21	22	1	1429	2	172	0	15	0	7	0	154	0	0	0	0	0	0	0	0	1	0
9	87	3	105	3	3	0	842	51	190	3	61	1	3	0	41	0	0	0	0	0	0	0	0	0	0
10	133	160	161	193	7	6	2459	57	157	8	38	2	7	0	102	3	0	0	0	0	0	0	1	0	0
11	153	40	183	47	3	6	4261	546	165	13	38	5	7	0	84	7	0	0	0	0	0	0	0	0	0
12	169	3	202	4	9	7	3376	35	69	0	15	1	4	0	60	0	0	0	0	0	0	0	0	0	0
13	99	2	118	3	4	4	2226	19	27	2	3	0	0	0	73	2	0	0	0	0	0	0	0	0	0
14	98	2	118	2	3	0	1254	2	51	0	7	0	0	0	32	0	0	0	0	0	0	0	0	0	0
15	50	0	125	0	0	0	1018	64	32	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0
16	128	1	334	3	2	2	729	4	56	0	6	0	0	0	45	0	0	0	1	0	0	0	0	0	0
17	119	0	301	0	1	0	1637	33	51	0	7	0	0	0	19	0	0	0	0	0	0	0	0	0	0
18	61	0	153	1	1	0	693	0	52	0	3	0	1	0	52	0	0	0	0	0	0	0	0	0	0
19	45	0	113	1	1	2	578	1	62	0	9	0	1	0	54	0	0	0	0	0	0	0	0	0	0
20	38	1	96	4	2	4	336	4	29	4	3	0	0	0	27	0	0	0	0	0	0	0	0	0	0
21	35	0	89	0	0	0	379	0	12	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	0
22	47	0	150	0	2	0	646	0	7	0	4	0	0	0	13	0	0	0	0	0	0	0	0	0	0
23	40	0	127	0	0	0	1014	7	12	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
24	49	3	156	10	5	0	1213	15	19	1	5	0	0	0	12	0	0	0	0	0	0	0	0	0	0
25	33	0	105	1	1	2	60	0	6	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
26	14	0	44	1	0	0	413	4	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	7	0	21	0	0	0	203	3	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
28	13	0	41	0	0	0	160	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
29	22	0	74	0	6	0	129	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
30	26	0	83	2	2	0	89	1	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TOT	7310	553	6935	507	1049	156	31703	916	3722	97	1625	21	84	0	2998	49	0	0	0	0	0	16	7	5	2

Appendix Table B.15. Outmigration for July, 1986 Prosser trap.

DAY	WSCHK ESTD	MORTS ESTD	WFCHK ESTD	MORTS ESTD	HSCHK ESTD	MORTS ESTD	HFCHK ESTD	MORTS ESTD	WSTH ESTD	MORTS ESTD	HSTH ESTD	MORTS ESTD	TROUT ESTD	MORTS ESTD	COHO ESTD	MORTS ESTD	JUN85 ESTD	SEP85 ESTD	NOV85 ESTD	SELAH ESTD	NACH ESTD	HRIV ESTD	HPOND ESTD	WILD ESTD	HYBRID ESTD
1	0	0	29	0	0	0	24	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2	0	0	65	0	7	0	25	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3	0	0	50	0	0	0	11	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	38	0	7	0	5	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	64	1	2	0	36	0	6	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
6	0	0	68	5	0	0	20	1	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
7	0	0	32	0	0	0	14	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
8	0	0	27	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	26	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11	0	0	27	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	13	1	0	0	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	31	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	17	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	12	2	2	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
16	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	21	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18	0	0	25	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
19	0	0	25	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	11	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
21	0	0	21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	11	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	7	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
28	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	11	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
31	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOT	0	0	738	9	30	1	158	3	19	0	2	0	0	0	19	0	0	0	0	0	0	0	0	0	0

Appendix C.

Prosser Diversion dam trap adult counts

April, 1986--July, 1986

and

Roza diversion dam trap adult counts

May, 1986--September, 1986.

Appendix Table C.1. Prosser diversion dam adult trap count for April, 1986.

Date	Right bank trap				Center trap				Cumulative passage			
	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
04/01/86	-	-	-	-	-	-	-	-	0	0	0	2071
04/02/86	n/o	n/o	n/o	n/o	0	0	0	1	0	0	0	2072
04/03/86	n/o	n/o	n/o	n/o	0	0	0	2	0	0	0	2074
04/04/86	n/o	n/o	n/o	n/o	0	0	0	1	0	0	0	2075
04/05/86	n/o	n/o	n/o	n/o	0	0	0	2	0	0	0	2077
04/06/86	n/o	n/o	n/o	n/o	0	0	0	15	0	0	0	2092
04/07/86	n/o	n/o	n/o	n/o	0	0	0	10	0	0	0	2102
04/08/86	n/o	n/o	n/o	n/o	0	0	0	17	0	0	0	2119
04/09/86	n/o	n/o	n/o	n/o	0	0	0	13	0	0	0	2132
04/10/86	n/o	n/o	n/o	n/o	0	0	0	5	0	0	0	2137
04/11/86	n/o	n/o	n/o	n/o	0	0	0	4	0	0	0	2141
04/12/86	n/o	n/o	n/o	n/o	0	0	0	0	0	0	0	2141
04/13/86	n/o	n/o	n/o	n/o	0	0	0	0	0	0	0	2141
04/14/86	n/o	n/o	n/o	n/o	0	0	0	4	0	0	0	2145
04/15/86	n/o	n/o	n/o	n/o	0	0	0	0	0	0	0	2145
04/16/86	n/o	n/o	n/o	n/o	0	0	0	2	0	0	0	2147
04/17/86	n/o	n/o	n/o	n/o	0	0	0	0	0	0	0	2147
04/18/86	n/o	n/o	n/o	n/o	0	0	0	6	0	0	0	2153
04/19/86	n/o	n/o	n/o	n/o	2	0	2	14	2	0	2	2167
04/20/86	n/o	n/o	n/o	n/o	1	0	1	7	3	0	3	2174
04/21/86	n/o	n/o	n/o	n/o	6	0	11	11	9	0	9	2185
04/22/86	n/o	n/o	n/o	n/o	25	0	6	6	34	0	34	2191
04/23/86	n/o	n/o	n/o	n/o	49	0	49	3	83	0	83	2194
04/24/86	n/o	n/o	n/o	n/o	28	0	28	2	111	0	111	2196
04/25/86	n/o	n/o	n/o	n/o	29	0	29	2	140	0	140	2198
04/26/86	n/o	n/o	n/o	n/o	27	0	27	2	167	0	167	2200
04/27/86	n/o	n/o	n/o	n/o	23	0	23	2	190	0	190	2202
04/28/86	n/o	n/o	n/o	n/o	95	0	95	2	285	0	285	2204
04/29/86	n/o	n/o	n/o	n/o	67	0	67	0	352	0	352	2204
04/30/86	n/o	n/o	n/o	n/o	68	0	68	4	420	0	420	2208
Monthly total	-	-	-	-	420	0	420	137	420	-	420	137
Seasonal total	-	-	-	-	420	0	420	2208	420	-	420	2208

Spring chinook (start of counting to 07/31), fall chinook (08/01 - 12/31), summer steelhead (08/01 - 05/01).
n/o = Not operating.

Appendix Table C.2. Prosser diversion dam adult trap count for May 1986.

	Right bank trap				Center trap				Cumulative passage			
Date	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
05/01/86	n/o	n/o	n/o	n/o	69	0	69	3	489	0	489	3
05/02/86	n/o	n/o	n/o	n/o	16	0	16	0	505	0	505	3
05/03/86	n/o	n/o	n/o	n/o	11	0	11	0	516	0	516	3
05/04/86	n/o	n/o	n/o	n/o	175	0	175	1	691	0	691	4
05/05/86	n/o	n/o	n/o	n/o	177	0	177	0	868	0	868	4
05/06/86	n/o	n/o	n/o	n/o	468	0	468	1	1336	0	1336	5
05/07/86	n/o	n/o	n/o	n/o	78	0	78	0	1414	0	1414	5
05/08/86	n/o	n/o	n/o	n/o	124	0	124	0	1538	0	1538	5
05/09/86	n/o	n/o	n/o	n/o	34	0	34	0	1572	0	1572	5
05/10/86	n/o	n/o	n/o	n/o	11	0	11	0	1583	0	1583	5
05/11/86	n/o	n/o	n/o	n/o	192	0	192	0	1775	0	1775	5
05/12/86	n/o	n/o	n/o	n/o	453	0	453	0	2228	0	2228	5
05/13/86	n/o	n/o	n/o	n/o	207	0	207	0	2435	0	2435	5
05/14/86	43	3	46	0	150	0	150	1	2628	3	2631	6
05/15/86	443	17	460	0	132	2	134	0	3203	22	3225	6
05/16/86	34	2	36	1	8	0	8	0	3245	24	3269	7
05/17/86	89	8	97	0	3	0	3	0	3337	32	3369	7
05/18/86	548	45	593	0	127	0	127	0	4012	77	4089	7
05/19/86	450	38	488	0	108	0	108	0	4570	115	4685	7
05/20/86	393	20	413	0	216	0	216	0	5179	135	5314	7
05/21/86	249	12	261	0	128	1	129	0	5556	148	5704	7
05/22/86	155	6	161	0	43	0	43	0	5754	154	5908	7
05/23/86	94	4	98	0	12	0	12	0	5860	158	6018	7
05/24/86	42	6	48	0	2	0	2	0	5904	164	6068	7
05/25/86	147	9	156	0	80	0	80	0	6131	173	6304	7
05/26/86	117	16	133	0	93	0	93	0	6341	189	6530	7
05/27/86	184	18	202	0	114	0	114	0	6639	207	6846	7
05/28/86	132	13	145	1	26	0	26	0	6697	220	7017	8
05/29/86	67	4	71	0	36	4	40	0	6900	228	7128	8
05/30/86	26	3	29	1	3	0	3	0	6929	231	7160	9
05/31/86	29	5	34	0	0	0	0	0	6958	236	7194	9
Monthly total	3242	229	3471	3	3296	7	3303	6	6538	236	6774	9
Seasonal total[a]	3242	229	3471	3	3716	7	3723	6	6958	236	7194	9

[a]Spring chinook (start of counting to 07/31), fall chinook (08/01 - 12/31), summer steelhead (08/01 - 05-01).
n/o = Not operating.

Table C.3. Prosser diversion dam adult trap count for June, 1986.

Date	Right bank trap				Center trap				Cumulative passage			
	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adult	Chinook jacks	Chinook total	Steelhead
06/01/86	8	0	8	0	8	1	9	0	6,975	237	7,211	9
06/02/86	10	1	11	0	4	0	4	0	6,988	238	7,226	9
06/03/86	6	1	7	0	4	0	4	0	6,998	239	7,237	9
06/04/86	4	5	9	0	5	0	5	0	7,007	244	7,251	9
06/05/86	5	0	5	0	12	0	12	0	7,024	244	7,268	9
06/06/86	10	1	11	0	18	4	22	0	7,052	249	7,301	9
06/07/86	38	6	44	0	38	4	42	0	7,128	259	7,387	9
06/08/86	86	12	98	0	105	2	107	0	7,319	273	7,592	9
06/09/86	74	10	84	0	70	0	70	0	7,463	283	7,746	9
06/10/86	108	9	117	0	115	0	115	0	7,686	292	7,978	9
06/11/86	76	10	86	0	52	1	53	0	7,814	303	8,117	9
06/12/86	33	2	37	0	26	4	30	0	7,875	309	8,184	9
06/13/86	18	1	19	0	2	0	2	0	7,895	310	8,205	9
06/14/86	20	1	21	0	0	0	0	0	7,915	311	8,226	9
06/15/86	11	0	11	0	2	0	2	0	7,928	311	8,239	9
06/16/86	17	0	17	0	15	0	15	0	7,960	311	8,271	9
06/17/86	18	1	19	0	26	0	26	0	8,004	312	8,316	9
06/18/86	20	2	22	0	15	0	15	0	8,039	314	8,353	9
06/19/86	4	0	4	0	24	0	24	0	8,067	316	8,381	9
06/20/86	14	1	15	0	3	1	4	0	8,084	316	8,400	9
06/21/86	54	5	59	0	25	1	26	0	8,163	322	8,485	9
06/22/86	60	0	60	0	15	1	16	0	8,238	323	8,561	9
06/23/86	47	4	51	0	3	1	4	0	8,288	328	8,616	9
06/24/86	21	2	23	0	0	0	0	0	8,309	330	8,639	9
06/25/86	8	0	8	0	3	0	3	0	8,320	330	8,650	9
06/26/86	7	2	9	0	4	0	4	0	8,331	332	8,663	9
06/27/86	22	5	27	3	2	0	2	0	8,355	337	8,692	12
06/28/86	9	0	9	0	0	0	0	0	8,364	337	8,701	12
06/29/86	8	2	10	0	8	0	8	0	8,380	339	8,719	12
06/30/86	4	2	6	2	2	0	2	0	8,386	341	8,727	14
Monthly total	822	85	907	5	606	20	626	0	1,428	105	1,533	5
Seasonal total[a]									8,386	341	8,727	14

[a]Spring chinook (start of counting to 07/31), fall chinook (08/01-12/31), summer steelhead (08/01-05/01).

Table C.4. Prosser diversion dam adult trap count for July, 1986.

Date	Right bank trap				Center trap				Cumulative passage			
	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
07/01/86	5	0	5	0	2	0	2	0	8,393	341	8,734	14
07/02/86	1	0	1	0	1	0	1	0	8,395	341	8,736	14
07/03/86	4	0	4	1	2	0	2	0	8,401	341	8,742	15
07/04/86	4	0	4	1	0	0	0	0	8,405	341	8,746	16
07/05/86	1	0	1	5	1	0	1	0	8,407	341	8,748	21
07/06/86	4	0	4	1	8	0	8	0	8,441	341	8,360	22
07/07/86	11	0	11	1	9	0	9	0	8,439	341	8,780	23
07/08/86	11	1	12	0	2	0	2	0	8,452	342	8,794	22
07/09/86	13	1	14	0	6	0	6	0	8,471	343	8,812	23
07/10/86	14	0	14	3	5	1	6	0	8,490	344	8,834	26
07/11/86	15	1	16	7	0	0	0	0	8,505	345	8,850	33
07/12/86	6	0	6	1	1	1	2	0	8,512	346	8,858	34
07/13/86	3	0	3	0	6	0	6	0	8,521	346	8,867	34
07/14/86	5	0	5	1	7	0	7	0	8,533	346	8,879	35
07/15/86	5	0	5	0	5	0	5	0	8,543	346	8,889	35
07/16/86	4	1	5	0	0	0	0	0	8,547	347	8,894	35
07/17/86	0	0	0	0	2	0	2	0	8,549	317	8,896	35
07/18/86	4	1	5	0	0	0	0	0	8,553	348	8,901	35
07/19/86	1	0	1	0	0	0	0	0	8,554	348	8,902	35
07/20/86	2	0	2	0	3	0	3	0	8,559	348	8,907	35
07/21/86	2	0	2	1	0	0	0	0	8,561	348	8,909	36
07/22/86	0	0	0	0	0	0	0	0	8,561	348	8,909	36
07/23/86	0	0	0	1	0	0	0	0	8,561	348	8,909	37
07/24/86	0	0	0	1	1	0	1	0	8,562	348	8,910	38
07/25/86	1	0	1	0	0	0	0	1	8,563	348	8,911	39
07/26/86	0	0	0	1	0	0	0	1	8,563	348	8,911	41
07/27/86	0	0	0	0	0	0	0	0	8,563	348	8,911	41
07/28/86	0	0	0	0	0	0	0	0	8,563	348	8,911	41
07/29/86	0	1	1	1	0	0	0	1	8,563	349	8,911	43
07/30/86	0	0	0	0	0	0	0	0	8,563	349	8,911	43
07/31/86	0	0	0	0	0	0	0	0	8,563	349	8,911	43
Monthly total	116	6	122	27	61	2	63		177	8	185	29
Seasonal total[a]									8,563	349	8,912	43

[a]Spring chinook (start of counting to 07/31), fall chinook (08/01-12/31), summer steelhead (08/01-05/01).

Appendix Table C.5. Roza diversion dam adult fish count for May 1986.

	Daily passage				Cumulative passage			
Date	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
05/01/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/02/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/03/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/04/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/05/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/06/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/07/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/08/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/09/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/10/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/11/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/12/86	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
05/13/86	6	1	7	0	6	1	7	0
05/14/86	2	0	2	0	8	1	9	0
05/15/86	10	1	11	0	18	2	20	0
05/16/86	10	0	10	0	28	2	30	0
05/17/86	29	7	36	0	57	9	66	0
05/18/86	16	3	19	0	73	12	85	0
05/19/86	61	7	68	0	134	19	153	0
05/20/86	64	7	71	0	198	26	224	0
05/21/86	21	1	22	0	219	27	246	0
05/22/86	20	1	21	0	239	28	267	0
05/23/86	42	0	42	0	281	28	309	0
05/24/86	33	1	34	0	314	29	343	0
05/25/86	86	26	112	0	400	55	455	0
05/26/86	90	21	111	0	490	76	566	0
05/27/86	181	33	214	0	671	109	780	0
05/28/86	124	13	137	0	795	122	917	0
05/29/86	133	2	135	0	928	124	1052	0
05/30/86	78	4	82	0	1006	128	1134	0
05/31/86	100	1	101	0	1106	129	1235	0
Monthly total					1106	129	1235	0
Seasonal total					1106	129	1235	0

n/o = Not operating.

Table C.6. Roza diversion dam adult fish count for June, 1986.

	Daily passage				Cumulative passage			
Date	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
06/01/86	32	0	32	0	1138	129	1267	0
06/02/86	23	0	23	0	1161	129	1290	0
06/03/86	34	0	34	0	1195	129	1324	0
06/04/86	39	2	41	0	1234	131	1365	0
06/05/86	139	12	151	0	1373	143	1516	0
06/06/86	125	3	128	0	1498	146	1644	0
06/07/86	17	0	17	0	1515	146	1661	0
06/08/86	7	0	7	0	1522	146	1668	0
06/09/86	19	0	19	0	1541	146	1687	0
06/10/86	35	1	36	0	1576	147	1723	0
06/11/86	41	0	41	0	1617	147	1764	0
06/12/86	28	1	29	0	1645	148	1793	0
06/13/86	25	0	25	0	1670	148	1818	0
06/14/86	42	7	49	0	1712	155	1867	0
06/15/86	34	0	34	0	1746	155	1901	0
06/16/86	40	1	41	0	1786	156	1942	0
06/17/86	44	2	46	0	1830	158	1988	0
06/18/86	28	4	32	0	1858	162	2020	0
06/19/86	16	2	18	0	1874	164	2034	0
06/20/86	35	3	38	0	1909	167	2076	0
06/21/86	31	2	33	0	1940	169	2109	0
06/22/86	24	4	28	0	1964	173	2137	0
06/23/86	70	5	75	0	2034	178	2212	0
06/24/86	61	5	66	0	2095	183	2278	0
06/25/86	65	3	68	0	2160	186	2346	0
06/26/86	30	3	33	0	2190	189	2379	0
06/27/86	26	3	29	0	2216	192	2408	0
06/28/86	24	2	26	0	2240	194	2434	0
06/29/86	17	0	17	0	2257	194	2451	0
06/30/86	22	2	24	0	2279	196	2475	0
Monthly total					1173	67	1240	0
Seasonal total					2279	196	2475	0

n/o = Not operating.

Table C.7. Roza diversion dam adult trap count for July, 1986.

	Daily passage				Cumulative passage			
Date	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
07/01/86	30	6	36	0	2309	202	2511	0
07/02/86	15	1	16	0	2324	203	2527	0
07/03/86	11	1	12	0	2335	204	2539	0
07/04/86	8	2	10	0	2343	206	2549	0
07/05/86	14	1	15	0	2357	207	2564	0
07/06/86	8	1	9	0	2365	208	2573	0
07/07/86	26	5	31	0	2391	213	2604	0
07/08/86	35	4	39	0	2426	217	2643	0
07/09/86	26	3	29	0	2452	220	2672	0
07/10/86	12	1	13	0	2464	221	2685	0
07/11/86	6	2	8	0	2470	223	2693	0
07/12/86	9	1	10	0	2479	224	2703	0
07/13/86	5	2	7	0	2484	226	2710	0
07/14/86	22	6	28	0	2506	232	2738	0
07/15/86	10	3	13	0	2516	235	2751	0
07/16/86	7	1	8	0	2523	236	2759	0
07/17/86	8	1	9	0	2531	237	2768	0
07/18/86	9	0	9	0	2540	237	2777	0
07/19/86	10	1	11	0	2550	238	2788	0
07/20/86	14	1	15	0	2564	239	2803	0
07/21/86	19	9	28	0	2583	248	2831	0
07/22/86	23	1	24	0	2606	249	2855	0
07/23/86	39	9	48	0	2645	258	2903	0
07/24/86	20	1	21	0	2665	259	2924	0
07/25/86	25	2	27	0	2690	261	2951	0
07/26/86	15	2	17	0	2705	263	2968	0
07/27/86	3	0	3	0	2708	263	2971	0
07/28/86	7	1	8	0	2715	264	2979	0
07/29/86	4	3	7	0	2719	267	2986	0
07/30/86	6	1	7	0	2725	268	2993	0
07/31/86	22	0	22	0	2747	268	3015	0
Monthly total	3242	229	3471	3	3296	7	3303	6
Seasonal total	3242	229	3471	3	3716	7	3723	6

Table C.8. Roza diversion dam adult fish count for August, 1986.

	Daily passage				Cumulative passage			
Date	Chinook adults	Chinook jacks	Chinook total	Steelhead	Chinook adults	Chinook jacks	Chinook total	Steelhead
08/01/86	9	1	10	0	2756	269	3025	0
08/02/86	10	2	12	0	2766	271	3037	0
08/03/86	5	0	5	0	2771	271	3042	0
08/04/86	29	8	37	0	2800	279	3079	0
08/05/86	6	1	7	0	2806	280	3086	0
08/06/86	6	1	7	0	2812	281	3096	0
08/07/86	6	0	6	0	2818	281	3099	0
08/08/86	1	0	1	0	2819	281	3100	0
08/09/86	2	0	2	0	2821	281	3102	0
08/10/86	2	0	2	0	2823	281	3104	0
08/11/86	3	0	3	0	2826	281	3107	0
08/12/86	3	0	3	0	2829	281	3110	0
08/13/86	0	0	0	0	2829	281	3110	0
08/14/86	7	0	7	0	2836	281	3117	0
08/15/86	2	0	2	0	2838	281	3119	0
08/16/86	3	0	3	0	2841	281	3122	0
08/17/86	0	0	0	0	2841	281	3122	0
08/18/86	1	0	1	0	2842	281	3123	0
08/19/86	1	0	1	0	2843	281	3124	0
08/20/86	1	0	1	0	2844	281	3125	0
08/21/86	2	0	2	0	2846	281	3127	0
08/22/86	6	0	6	0	2852	281	3133	0
08/23/86	1	0	1	0	2853	281	3134	0
08/24/86	2	0	2	0	2855	281	3136	0
08/25/86	4	0	4	0	2859	281	3140	0
08/26/86	7	0	7	0	2866	281	3147	0
08/27/86	8	0	8	0	2874	281	3155	0
08/28/86	10	0	10	0	2884	281	3165	0
08/29/86	16	1	17	0	2900	282	3182	0
08/30/86	14	0	14	0	2914	282	3196	0
08/31/86	9	0	9	0	2923	282	3205	0
Monthly total					176	14	190	0
Seasonal total					2923	282	3205	0

Table C.9. Roza diversion dam adult trap count for September, 1986.

Date	Daily passage: Chinook adults	Daily passage: Chinook jacks	Daily passage: Chinook total	Daily passage: Steelhead	Cumulative passage: Chinook adults	Cumulative passage: Chinook jacks	Cumulative passage: Chinook total	Cumulative passage: Steelhead
09/01/86	4	0	4	0	2927	282	3209	0
09/02/86	3	0	3	0	2930	282	3212	0
09/03/86	2	0	2	0	2932	282	3214	0
09/04/86	1	0	1	0	2933	282	3215	0
09/05/86	2	0	2	0	2935	282	3217	0
09/06/86	8	0	8	0	2943	282	3225	0
09/07/86	0	0	0	0	2943	282	3225	0
09/08/86	1	0	1	0	2944	282	3226	0
09/09/86	1	0	1	0	2945	282	3227	0
09/10/86	0	0	0	0	2945	282	3227	0
09/11/86	1	0	1	0	2946	282	3228	0
09/12/86	2	0	2	0	2948	282	3230	0
09/13/86	0	0	0	0	2948	282	3230	0
09/14/86	0	0	0	0	2948	282	3230	0
09/15/86	1	0	1	0	2949	282	3231	0
09/16/86	0	0	0	0	2949	282	3231	0
09/17/86	0	0	0	0	2949	282	3231	0
09/18/86	8	0	8	2	2957	282	3249	2
09/19/86	0	1	1	0	2957	283	3240	2
09/20/86	0	0	0	0	2957	283	3240	2
09/21/86	1	0	1	0	2958	283	3241	2
09/22/86	2	0	2	0	2960	283	3243	2
09/23/86	0	0	0	0	2960	283	3243	2
09/24/86	2	0	2	0	2962	283	3245	2
09/25/86	0	1	1	0	2963	284	3246	2
09/26/86	1	0	1	0	2964	284	3247	2
09/27/86	0	0	0	0	2964	284	3247	2
09/28/86	0	0	0	0	2964	284	3247	2
09/29/86	4	0	4	0	2968	284	3251	2
09/30/86	0	0	0	0	2968	284	3251	2
Monthly total					44	2	46	2
Seasonal total					2967	284	3251	2

Table C.9. Roza diversion dam adult trap count for September, 1986.

Date	Daily passage: Chinook adults	Chinook jacks	Chinook total	Steelhead	Cumulative passage: Chinook adults	Chinook jacks	Chinook total	Steelhead
09/01/86	4	0	4	0	2927	282	3209	0
09/02/86	3	0	3	0	2930	282	3212	0
09/03/86	2	0	2	0	2932	282	3214	0
09/04/86	1	0	1	0	2933	282	3215	0
09/05/86	2	0	2	0	2935	282	3217	0
09/06/86	8	0	8	0	2943	282	3225	0
09/07/86	0	0	0	0	2943	282	3225	0
09/08/86	1	0	1	0	2944	282	3226	0
09/09/86	1	0	1	0	2945	282	3227	0
09/10/86	0	0	0	0	2945	282	3227	0
09/11/86	1	0	1	0	2946	282	3228	0
09/12/86	2	0	2	0	2948	282	3230	0
09/13/86	0	0	0	0	2948	282	3230	0
09/14/86	0	0	0	0	2948	282	3230	0
09/15/86	1	0	1	0	2949	282	3231	0
09/16/86	0	0	0	0	2949	282	3231	0
09/17/86	0	0	0	0	2949	282	3231	0
09/18/86	8	0	8	2	2957	282	3249	2
09/19/86	0	1	1	0	2957	283	3240	2
09/20/86	0	0	0	0	2957	283	3240	2
09/21/86	1	0	1	0	2958	283	3241	2
09/22/86	2	0	2	0	2960	283	3243	2
09/23/86	0	0	0	0	2960	283	3243	2
09/24/86	2	0	2	0	2962	283	3245	2
09/25/86	0	1	1	0	2963	284	3246	2
09/26/86	1	0	1	0	2964	284	3247	2
09/27/86	0	0	0	0	2964	284	3247	2
09/28/86	0	0	0	0	2964	284	3247	2
09/29/86	4	0	4	0	2968	284	3251	2
09/30/86	0	0	0	0	2968	284	3251	2
Monthly total					44	2	46	2
Seasonal total					2967	284	3251	2